
Thomas Hawkes Tanner. M.D.
Virtus in arduis

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HEALTH AND DISEASE

AS INFLUENCED BY THE

DAILY, SEASONAL, AND OTHER CYCLICAL CHANGES IN THE HUMAN SYSTEM.

BY

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TO

SIR BENJAMIN COLLINS BRODIE, BART.,

P.R.S., D.C.L.,

SERJEANT-SURGEON TO THE QUEEN, MEMBER OF THE INSTITUTE OF FRANCE,
&c. &c. &c.

DEAR SIR BENJAMIN,

I am deeply indebted to you for the sympathy and encouragement without which it is very unlikely that in the midst of professional engagements I should have prosecuted a daily series of physiological researches through several successive years. Whatever knowledge has been attained is therefore in no small part due to yourself, and I am happy in having been honoured with the permission to inscribe to you the following attempt to apply some of the results to the requirements of practice.

My earnest wish is that you may long be spared to enjoy your high position, and to lend your powerful aid in the furtherance of scientific research and the advancement of the public interests of our Profession.

I have the honour to be,

Dear Sir Benjamin,

Your grateful humble servant,

EDWARD SMITH.

PREFACE.

The following work has been written with a view to supply a deficiency which exists in medical literature and to offer the results of a series of inquiries in aid of our knowledge on the two functions of the Medical Practitioner—the preservation of health and the treatment of disease.

The former fact will be appreciated when it is stated that no work of modern date exists in which the cyclical changes proceeding in the human system are described, or in which even the influence of season is cited at any length in reference to the causation and treatment of disease. In this respect the present age appears to be singularly behind former ages. In the days of the early medical fathers, and even in the less remote times of the astrologers, the influence of season in the treatment of disease was constantly recognised, but the present era attaches little value to the imperfect knowledge of those times, and has not brought to bear upon this question the faculty for exact research which is beginning to be its own charac-

teristic. Nevertheless, whilst there may be but little of the lex scripta, there is much unwritten law upon this subject, and perhaps no kind of knowledge more largely influences the conduct of men than that to be now discussed. It may, therefore, be hoped that an effort, however humble, to place our knowledge of this department upon a more exact and scientific basis will not be unacceptable.

The latter reason is chiefly connected with the author's inquiries so far as relates to the changes proceeding in the cycle of the day, week, and year. These have been made upon himself and others both in health and disease, and have been prosecuted almost without intermission through a period of six years. They have in part appeared in the Transactions of the learned societies, and are now for the first time embodied and offered to the notice of the Profession. It is not necessary to refer to them further, except to state that the inquiries concerning urea, having been in progress until the day of the publication of this work, are not given with the detail which might otherwise have been thought desirable. For some information upon these subjects, and for much upon the cyclical changes proceeding in the ages and generations of man, the author is indebted to various excellent writers who are duly quoted in the body of the work.

In reference to the form in which the work appears

it may be proper to state, that the separation of the details of scientific research from the application of the knowledge obtained by them to the preservation of health and the treatment of disease, and also the arrangement of the latter under the head of propositions, have been adopted with a view to the convenience of the reader, clearness of exposition, and readiness of reference, and will, it is hoped, meet with approbation. At the same time it cannot be denied that there may be a loss of force of argument in detaching the premises from the conclusion, and to some extent a parade of headings or propositions which might not in every instance have been otherwise requisite.

The author gratefully acknowledges much kind aid received at various times from Professors Sharpey and Carpenter, Williamson and Frankland, and from Dugald Campbell, Esq., and other gentlemen, and also the courtesy by which he has been permitted to use illustrations belonging to the Royal Society, the Royal Medical and Chirurgical Society, and the British Medical Association.

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Cavendish Square, London, W.
June, 1861.

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DESCRIPTION OF DIAGRAMS.

[*The Author is responsible for the Diagrams.*]

HOURLY PULSATION AND RESPIRATION WITH AND WITHOUT FOOD.

No. Page.

1 8 Represents the hourly rate of pulsation in a female child under two conditions:—1st. The large dotted line shows the rate on the average of three days and nights with ordinary food. 2nd. The small dotted line represents the rate on the occasion of a fast until the dinner, at $2\frac{1}{2}$ P.M., and then the rate with the ordinary meals.

The thick line shows the hourly rate of respiration on the average of three days and nights.

The shaded parts are the hours of darkness.

The hours, and the period of meals, are engraved on the enclosing circle, and the scale in several parts of the diagram.

HOURLY PULSATION AND RESPIRATION.

2 15 Indicates the rate of pulsation and respiration at every hour in three persons in phthisis. The shaded parts represent darkness, and the thick perpendicular lines are placed at the hours of meals.

The letter S signifies that the patient was then asleep; and $\frac{1}{2}$ S that he slept lightly.

The different characters of the lines in both pulsation and respiration represent different persons.

HOURLY RESPIRATION.

17 Represents the hourly rate of respiration in two female phthisical patients. The letters S and $\frac{1}{2}$ S signify sleep and light sleep.

HOURLY PULSATION AND RESPIRATION.

3 18 Show the hourly rate of pulsation and respiration in a phthisical woman, on the average of six days and nights. The outer or enclosing dotted line represents the pulsation

No. Page.

at each of the 24 hours, and the inner thick line the respiration at the same period. The shaded parts represent darkness.

Carbonic Acid Apparatus.

4 24 The author's apparatus for the collection of carbonic acid in the expired air, and the measuring of the inspired air.

Carbonic Acid, Period of Day, Temperature, and Fasting.

5 29 Fig. 1 shows the quantity of carbonic acid emitted by the author on two occasions (March 12 and May 15), with food, and on one occasion (July) whilst fasting. The meal hours are indicated by the thick perpendicular lines.

Figs. 2 and 3 show the relation of the expired carbonic acid to temperature. In the former the rate of emission per hour in the author and Mr. Moul is given on a series of days with the average temperature of those days. In the latter, the weight of carbonic acid to each degree of temperature, and the loss of carbonic acid for each degree of temperature, are delineated.

Urea and Urinary Water.

6 38 Shows the hourly rate of excretion of urea and urinary water by the author. In Figs. 1, 2, 3, 4, and 5, the periods of emission were at longer intervals than one hour, except before mid-day, but in the part of the diagram marked "hourly excretion," the observations were made at every hour of the day.

The quantity of urea found in each ounce of urine is also delineated in the five first figures.

The emission during the night is recorded on the average of the whole period.

The periods of meals are marked by the perpendicular thicker lines in the parts of the diagram marked "hourly excretion."

Effect of Season over Respiration and Pulsation.

7 152 Represents the quantity of carbonic acid expired, the quantity of air inspired, and the rate of pulsation and respiration in the author and Mr. Moul, between 7 and 8 A.M., before breakfast, and in the sitting posture, daily throughout the year.

The temperature with the wet and dry bulbs is also recorded.

The letter M at the head of the diagram represents Monday.

Pulsation and Respiration, with Day of the Week and Season.

Season of Birth and Vitality.

Season, Carbonic Acid, and Disease.

ERRATA.

Page	19, line	24,	*for*	"following"	*read*	"indicated."
,,	95, last line		,,	"weakened"	,,	"working."
,,	140, line	2,	,,	"hour"	,,	"minute."
,,	187 ,,	27,	,,	"a wine"	,,	"an ale."
,,	189 ,,	27,	,,	"only"	,,	"chiefly."
,,	236 ,,	8,	,,	"desire"	,,	"device."
,,	238 ,,	2,	,,	"Equinoxes"	,,	"Equinox."
,,	247 ,,	14,	,,	"Table No. 32"	,,	"Table No. 30."
,,	331 note		*after*	"quantity"	*add*	"of grains."
,,	391 line	25,	*for*	"thus"	*read*	"then."
,,	391 ,,	27,	,,	"possible"	,,	"impossible."

DAILY CYCLE.

CHAPTER I.

SCIENTIFIC RESEARCHES.

1. It will be convenient, in discussing the daily cycle of changes in the human system, to separate the details of scientific research from the statement of the doctrines which they teach in reference to health and disease. This chapter will therefore contain an account of the changes which occur with the use of ordinary food and during fasting, in reference to the rate of pulsation and the functions of the lungs and kidneys.

PHENOMENA WITH ORDINARY FOOD.

Pulsation and Respiration.

2. *In Health.*—The inquiry into the variations in the rate of pulsation and respiration is not by any means a new one, except so far as relates to the completion of the cycle of the day and night. We are indebted to Dr. Kiell, Dr. Robinson,[1] and Dr. Fal-

[1] "Animal Economy," 1732.

coner[1] for valuable records made during the last century; and in our own day M. Quetelet, Dr. Knox,[2] and Dr. Guy[3] have occupied the most conspicuous place in these investigations. Cullen stated that there were two natural accelerations in the day corresponding somewhat with the periods of exacerbation in fever; and, indeed, all observers until the time of Knox (1815), including Senac,[4] Haller, and Sir John Floyer,[5] had affirmed the fact that the pulsation is more frequent in the evening than in the morning.

3. Dr. Knox corrected and enlarged these observations by a new series of inquiries upon himself, and showed that whilst the pulsation was 2·2 more frequent at 5 P.M. after dinner than it had been after breakfast, it was 8 less than the latter at about midnight after the supper had been taken. These observations were, however, made at distant periods, and did not aid in tracing the progression of changes through the day.

4. Robinson and Falconer made hourly inquiries from 8 A.M. to 11 P.M. at intervals for lengthened periods, viz., during twelve weeks and three weeks respectively, in Dr. Robinson's inquiries, and more than five months in those of Dr. Falconer, but not at the same hours on each day, and the following table shows the result obtained by them.

[1] "Observations on the Pulse," 1796.

[2] "Traité du Cœur."

[3] "Physician's Pulse Watch," vol. i. p. 156.

[4] "Edinb. Med. and Surg. Journal," 1815.

[5] "Guy's Hospital Reports," and Hooper's "Physician's Vade Mecum."

TABLE No. 1.

		Breakfast.				Dinner.	
Hour	8	9	10	11	12	1	2	3
Robinson A.	65	67	70	73	71	69	70	77
Robinson B.	66	71	72	68	69	67	67	75
Falconer, Æt. 50	63½	64	66	78·9	79	68·5	67·5	69·4
Hour	4	5	6	7	8	9	10	11
Robinson A.	77	77	77	76	76	74	74	76
Robinson B.	81	84	81	79	77	78	78	79
Falconer, Æt. 50	74	75	71	74	76	85	79·5	80·5

5. In reference to this table Dr. Falconer remarks: "It appears that the pulse is slower in the morning than at any other time of the day, and it grows somewhat quicker before breakfast, and a little more so after it. It grows slower again before dinner, and quicker immediately after dinner, and the quickness acquired by this meal continues for about three or four hours, and then abates a little and continues in that state without any considerable change, in bodies which eat and drink little at night, till they go to rest."

6. In these experiments there was not rigid attention paid to the effect of exertion, posture, and other disturbing agencies, but both of these gentlemen knew well that food, exertion, and posture exercised great influence over the pulse.

7. Dr. Robinson noticed that the increase in the

standing over the sitting posture varied from 1 to 13 pulsations per minute; and whilst Dr. Falconer agreed in the fact of there being an increase under those conditions, he could not from his own observations deduce any general results. Dr. Robinson states that the average pulsation in the lying posture was 64, in sitting 68, and in standing 78, whilst when walking at the rate of 2 and 4 miles per hour respectively, it was 74 and 100 per minute, and when running 150 per minute or more.

8. The effect of food was to cause an increase in Dr. Robinson's inquiries of $\frac{1}{22}$ and $\frac{1}{11}$ after breakfast, and $\frac{1}{10}$ and $\frac{1}{8}$ after dinner; and Sir John Floyer ascertained that the pulse was much quickened after he had drunk two dishes of hot coffee. Dr. Robinson also noticed that fermented liquors increased the pulsation, but only in those unaccustomed to their use.

9. Dr. Knox's labours were chiefly directed to prove that the evening pulsation is not more frequent than that of the morning, and he also affirmed the important facts that in the evening digestion is less easily performed, and that a given food then causes less increase in the pulsation than occurs in the earlier periods of the day.

10. Dr. Guy's researches are the most precise and extended of any which have preceded them, and embrace the questions, amongst others, of sex, age, posture, and period of the day. He found the difference in the rate of pulsation in the standing over the sitting, and the sitting over the lying posture in

males to be respectively 10 and 5 pulsations, or a total of 15 pulsations per minute, and the true effect of change of posture in the male is more than twice as great as in the female. This result of posture is not due to muscular exertion employed in effecting the change. Dr. Guy also fully investigated the proportion of the rate of respiration to that of pulsation.

11. These varied and numerous inquiries have afforded much information, but were deficient in that they did not in any case embrace the whole cycle of the twenty-four hours, and were not made under conditions so precisely parallel that they could be advantageously compared with each other, and hence it was desirable to make such a new series of observations as by their duration, the number of persons under observation, the uniformity in the conditions of the inquiry, and the extreme regularity in the period and mode of making the observations, should afford complete cycles and conditions which should render the results entitled to credit. To this end two sets of inquiries were set on foot, one in reference to health,[1] and the other in cases of phthisis[2], the former embracing hourly observations on five persons, including children, and extending over three days and nights; and the latter on six adults of both sexes, extending over six days and nights without intermission. The general conditions imposed were, precision in the hours of meals and of rising and retiring to rest, absolute rest during

[1] "Med. Chi. Trans.," 1856. [2] The same.

at least five minutes before each inquiry, and rigid attention to the hour, to the order of the cases, and to the method of counting and registering the rate of the functions. The posture selected was that of lying, since that alone was possible during sleep, and it is important to bear in mind that a considerable addition to that rate must be made if we would ascertain the rate in the sitting and the standing postures; but for the purpose of showing the progressive changes throughout the day either of the postures uniformly maintained is of nearly equal value. The true effect of posture and its variations during the day was determined by a third series of inquiries, in which the rate in each posture was determined at four periods of the day in several persons in health, and at 8 A.M. and 4 P.M. in fifteen phthisical persons during the space of a month, and to this we shall have occasion to refer.

12. The table, No. 2, contains the average rate of pulsation and respiration on three days, deduced from hourly observations made in the month of October upon two female children, æt. six and eight-and-a-half years, two female adults, and ourself, all in perfect health, and taking a suitable amount of food at 8½ A.M., 12½ P.M., 5½ P.M., and 8½ P.M. The four former represent the true effect of the ordinary conditions under which men live as respects food, exertion, rest, and sleep; but as we were awake during the whole period, and ate food twice during each night, the observations upon ourself must be regarded as made under exceptional conditions. There is, however, a

TABLE No. 2,

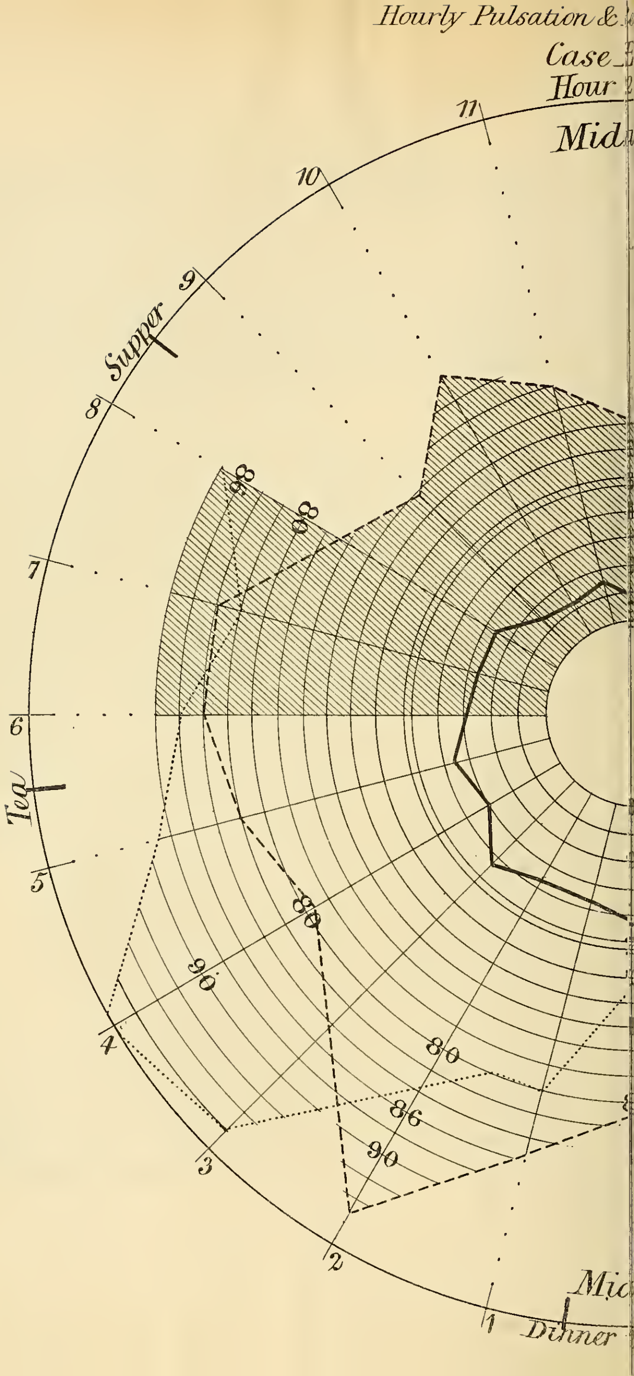
SHOWING THE RATE OF PULSATION AND RESPIRATION AT EACH HOUR OF THE DAY AND NIGHT, IN THE LYING POSTURE, ON THE AVERAGE OF THREE DAYS.

		Midnight.								Break.				Midday. Din.						Tea.		Sup.			
	Hour	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Pulsation.	Æt. 6	89·3	85	88·6	87	90	92	94·6	92·6	90·3	103	102	93	91	97·3	99·6	99	96·6	96	98·3	99·	91·6	94·	92·6	95·6
	8½	71.3	73.6	72·6	71	76·3	71·3	81	77·3	77·3	93·3	85	82·3	81·3	85·6	95·3	85	80	82	84	84·6	78·	73·6	79·3	76·6
	33	75.6	71.6	71	69·3	67·6	76	76·3	76	66·3	79	79·6	72·3	71·6	76·6	82·3	76·3	72·6	69·3	71·3	73·3	71·3	70·3	74	95·3
	36	71.6	71	70	66	65·3	68	67·6	68·6	67·3	78	79 6	77·3	72·6	77·6	80	78	77·3	75·3	72	78·6	69·	71	68·6	66
	39	58	56·6	61	61·3	60	60·6	61·3	62	56·3	66	65·3	64·3	57·6	62·6	63·6	62	57·3	59	60	57·6	58·6	60	64·3	62·3
Respiration.	Æt. 6	16	15·6	17·1	15·8	17	17·3	17·8	18·6	20·3	25·3	24·6	23·5	22·8	24	25·5	25·6	23·5	23	23·6	22·6	21·3	21·3	16·5	16·8
	8½	17.3	16.5	16·8	16.6	17·3	17·3	17·8	20·6	23·3	23·6	26	24·8	24·3	23·6	23·8	24·5	21·8	23	22·5	21·3	21·8	19·1	18·3	19·
	33	16.6	16·5	16·1	15·6	15·6	15·3	16·5	16·5	14·5	19·6	20	21	19·1	20·8	20·8	20·1	19·6	18·3	21·8	21·8	20·8	18·1	17·3	17·8
	36	18.6	16·8	17·3	16·3	17·3	16·6	16	17·3	16	20	20	20	19	19·3	18·7	19	18·1	18·5	19·1	17·5	17·5	18·3	17·	16·8
	39	16.1	17·1	16·5	16·5	16·1	16·8	17·1	15·5	16·6	19	19·3	19·3	18	19·3	19·7	19·5	19·	17·6	19·7	19·5	18·5	17·6	17·5	17·6

general correspondence in all the inquiries and in those of every day which may first claim our attention.

13. The Diagram, No. 1, represents the same facts in reference to the case æt. eight, and is inserted on account of the striking manner in which it represents to the eye the hourly variations of the day and night.

14. It will be observed on examining the table and diagram, that in all the cases alike the rate of both pulsation and respiration was increased during the day and decreased during the night, and as these changes did not occur abruptly, there was a period of increase in the morning and of decrease in the evening, so that when represented as in Diagram No. 2, they show a series of arches alternately erect and inverted, the former representing the elevation of the day and the latter the depression of the night. The amount of depression in the rate of pulsation in relation to the greatest elevation varied in the different persons, but not in any definite relation to age, for whilst in the elder child the greatest rate was $\frac{1}{2 \cdot 9}$ more than the least rate, in the younger it was $\frac{1}{4 \cdot 6}$, whilst in the adults it was $\frac{1}{4 \cdot 1}$ and $\frac{1}{4 \cdot 5}$, and in ourself $\frac{1}{5 \cdot 8}$. In reference to the rate of respiration, however, there was a progressive decrease in this proportion as age advanced, the increase of the maximum over the minimum being in the order of age as shown in the following Table :—


Hourly Pulsation &
Case
Hour
Mid
11
10
9
Supper
8
98
98
7
6
Tea
5
98
96
4
80
86
90
3
2
1
Mid
Dinner

espiration. (Pages 8, 20, 46.)

t. 8.

DIAGRAM Nº 1
To face Page 8.

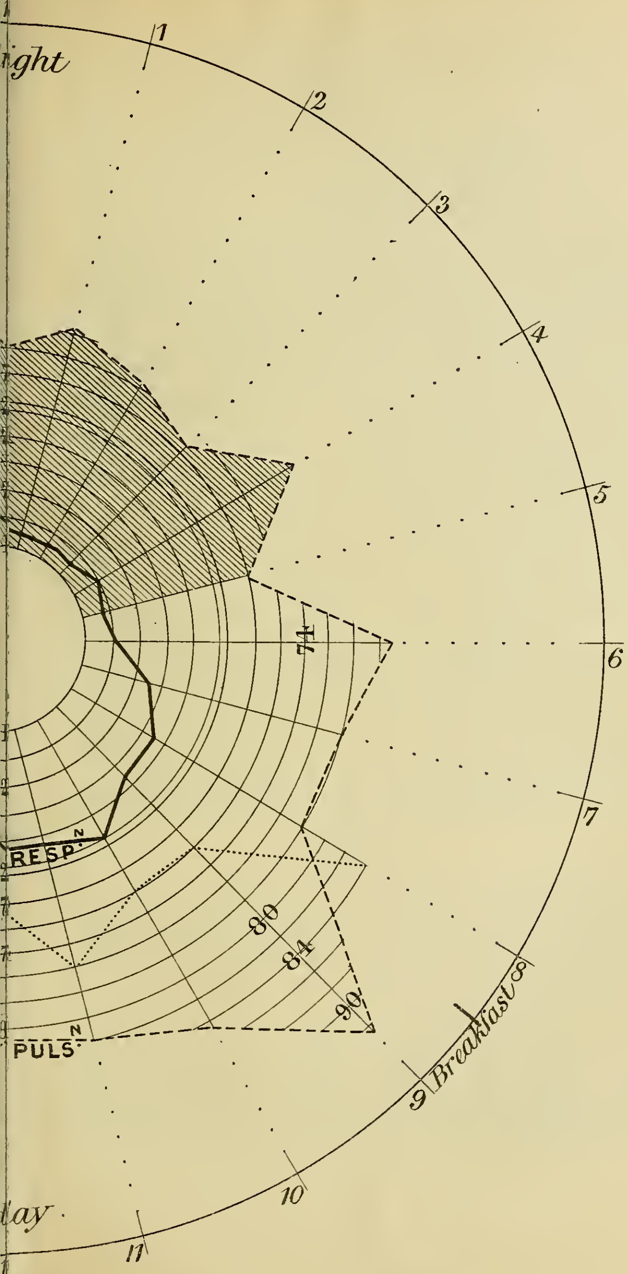


TABLE No. 3.

Æt. years	6	8½	33	36	39
	$\frac{1}{1\cdot5}$	$\frac{1}{1\cdot6}$	$\frac{1}{2}$	$\frac{1}{2\cdot7}$	$\frac{1}{4}$

15. The next point worthy of notice is the rapid and great variations in the rate at the several hours of the day. These are evidently much greater in the day than in the night, and in the former we find three or four marked elevations alternating with an equal number of depressions. The elevations follow the various meals, and are commonly the highest after the breakfast and tea, and within two or three hours after the meal. The depressions precede the taking of food, and of these that which precedes the breakfast is by far the greatest. The periods of lowest pulsation during the day were commonly 8 A.M. and midday, or the periods immediately preceding the breakfast and dinner.

16. The average increase in the rate of pulsation per minute due to the meals was as follows :—

TABLE No. 4.

Æt. years	6	8½	33	36	39
Increase from Breakfast	14·6	16·6	16·3	13·	12·3
,, Dinner...	9·3	17·6	10·6	11·5	11·3
,, Tea	5·6	8·3	6·3	7·3	3

17. The supper scarcely affected the rate. The average increase per minute in the rate of respiration in all the cases combined was, after breakfast 4·4,

dinner 2·1, and tea 2·1, and of pulsation 15, 12, and 6, in the same order. The increase in the rate of respiration at the breakfast was sometimes more than $\frac{1}{3}$, but it was less than that amount at dinner, and at both dinner and tea there were instances in which no increase was observed.

18. There was also an increase observed during the act of eating which disappeared in the intervals of the courses. We were at first unwilling to admit these results as due to the above-mentioned cause, but there can be no doubt that they did occur, and chiefly in the sensitive systems of the children. The temporary increase recorded was oftentimes twelve to fifteen pulsations per minute, as is recorded in Table No. 5.

TABLE No. 5,

Showing the Increase in the Rate of Pulsation, during Meals, in Two Children. The * implies that the Children were then Eating.

In Minutes.	Breakfast. Æt. 6.	Dinner. Æt. 8.		
		Ordinary.		After Long Fast.
5	7*	8*	25*	26*
10	31*	16*	7	14
15	17	16	37*	32*
20	31*	16	35*	28
25	27	26*	21	
30	19	18		
35	31*			
40	27			
45	17			
50	23			

19. The increase recorded in this table comprehends both that which is due to the action of the food and that resulting from the act of eating, but the two results may be readily dissociated. The greatest total increase observed in the adults was twenty-three pulsations per minute, and the effect of eating was much less pronounced in them than in the children.

20. Thus the general course in the daily cycle of pulsation and respiration is as follows:—

21. In the evening, from 7 to 9 P.M., there is an evident tendency in the rate to decline, and with some slight variations this is continued progressively through the following hours until from 1 to 3 A.M., when the rate is at its minimum. During the next two hours there is a slight tendency to increase, but it is very gradual until the usual hour of rising, when it will have attained an increase of several pulsations per minute. Immediately after the breakfast has been taken there is a rapid and great increase, which attains its maximum in the second hour afterwards, after which it declines greatly in an hour, and loses from ten to fifteen pulsations immediately before the dinner. After the dinner has been taken there is another increase, but the rate is seldom raised so high as that which follows the breakfast, and the highest point is attained in the second or third hour. This again is followed by a decrease which precedes and a subsequent increase which follows the tea, when a point as high as that which follows the breakfast is usually found; and lastly there is the final decrease,

which is usually progressive notwithstanding that supper may be taken at a later hour. When dinner had been taken at a later hour than that above indicated, the rate of the functions followed the same course as that now given, except that there was not any important increase after mid-day until the dinner hour. The rate remained low, but not uniform, from 12 to 1 P.M. until the dinner hour.

22. The extreme difference was sometimes thirty pulsations per minute, and was the greatest in the children.

23. The ratio of the two functions varied with each hour of the day, but was the highest during the day, and the lowest during the night, as shown in table No. 6.

24. The ratio is dependent rather upon respiration than pulsation, so that the high ratio of the day is due to the fact that whilst the rate of both functions is then increased, that of respiration is increased disproportionately. The extremes were as 1 to 2·9 and as 1 to 5·7, or the larger was double of the smaller ratio, but there was no ratio nor any progression of ratios which was absolutely uniform on consecutive days.

25. The effect of posture is very different in different persons and at various times, both of the same and different days, so that averages give but a very imperfect view of the result. We do not, however, purpose entering upon the general question, and shall only indicate the variations which have been observed by us at different periods of the day. Table No. 7 exhibits the results of an inquiry made upon four

TABLE No. 6.

Ratio of Respirations to Pulsations in the Lying Position at each Hour, on the average of Three Days and Nights, the Respirations being unity.

	A.M.								Break.			
Hour.	12	1	2	3	4	5	6	7	8	9	10	11
Æt. 6	5·5	5·4	5·1	5·5	5·3	5·3	5·3	5·	4·4	4·1	4·1	3·9
8½	4·1	4·4	4·3	4·2	4·4	4·1	4·5	3·7	3·3	3·9	3·2	3·3
33	4·5	4·3	4·4	4·4	4·3	4·9	4·6	4·6	4·5	4·	4·	3·4
36	3·8	4·2	4·	4·	3·7	4·1	4·2	3·9	4·2	3·	4·	3·8
39	3·6	3·3	3·7	3·7	3·7	3·9	3·4	4·	3·3	3·4	3·3	3·3

	Din. P.M.					Tea.			Sup.			
Hour.	12	1	2	3	4	5	6	7	8	9	10	11
Æt. 6	3·9	4·	3·9	3·8	4·1	4·1	4·1	4·4	4·3	4·2	5·6	5·7
8½	3·3	3·6	4·0	3·4	3·6	3·5	3·7	3·9	3·5	3·8	4·3	4·
33	3·7	3·7	3·9	3·8	3·7	3·7	3·2	3·3	3·4	3·8	4·2	4·2
36	3·8	4·	4·3	4·1	4·2	4·2	3·7	4·4	3·9	3·8	4·	3·9
39	3·2	3·2	3·2	3·1	3·	3·4	3·	2·9	3·1	3·4	3·6	3·5

persons on three successive days in October, at 8 A.M., midday, 5 P.M., and 8 P.M.

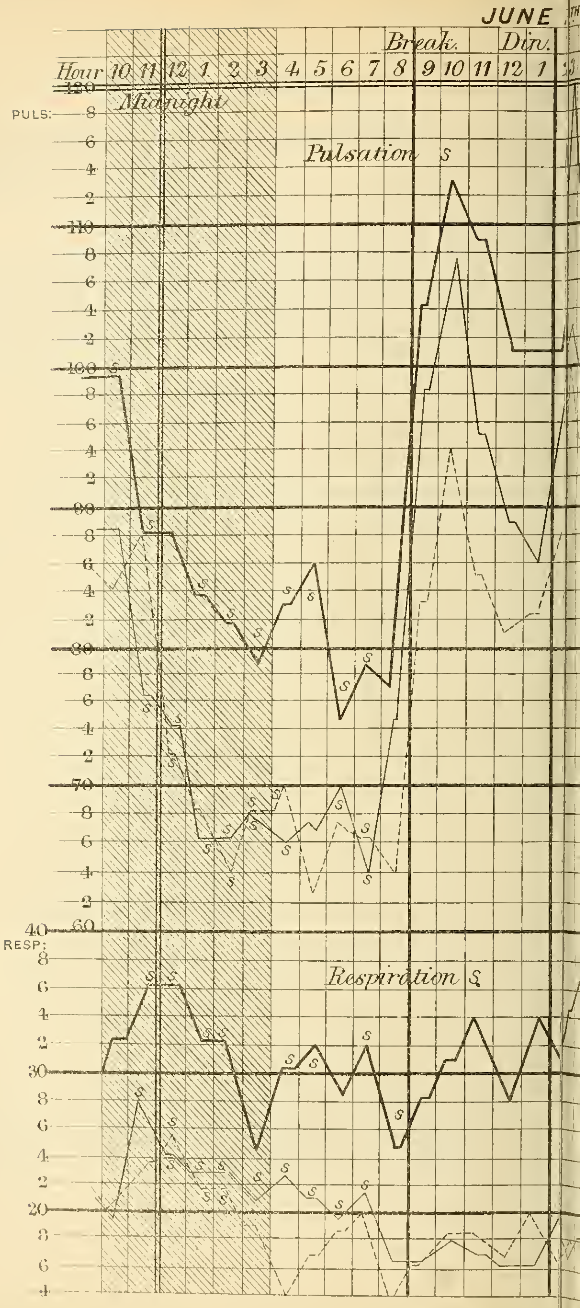
TABLE No. 7,

SHOWING THE TOTAL AVERAGE INCREASE IN THE RATE OF PULSATION AND RESPIRATION IN THE SITTING AND STANDING POSTURES OVER THAT WHILST LYING, IN TWO CHILDREN AND TWO FEMALE ADULTS, AT FOUR PERIODS OF THE DAY, BEFORE MEALS.

	Æt. 6.		Æt. 8½.		Æt. 33.		Æt. 39.	
	Puls.	Resp.	Puls.	Resp.	Puls.	Resp.	Puls.	Resp.
8 A.M.								
Sitting . .	7	– ·5	– ·3	– ·5	12	2·5	5	–1·5
Standing .	7	0	13	2·5	27	4·5	9	– ·5
MIDDAY.								
Sitting . .	12	0	1	·75	9	2·9	5·6	–1
Standing .	10·3	1	6	–2	14·6	3·5	8	·35
5 P.M.								
Sitting . .	2·6	–1	2·6	1·1	7·3	2·3	1·3	– ·5
Standing .	8·3	– ·3	16	1·8	12	1·5	7	– ·3
8 P.M.								
Sitting . .	11·5	1	9·5	1·25	3·5	– ·25	3	–1·5
Standing .	17	1·75	19	1·75	10	– ·25	7	·75

26. This table shows in a striking manner the difference in the effect of posture at different periods of the day upon the rate of the functions in children

Hourly Pulsation & Respir



...ion in Phthisis. (Pages 8, 15.)

DIAGRAM No. 2.
To face page 15.

and in adults. In both the children the effect was much greater at 8 P.M. than at any of the other periods, and particularly the effect of the standing posture, whilst in the adults the converse was observed. In one of the children the increase before the dinner and the supper was much greater than that before the other meals, whilst in the elder child the effect of the standing posture was the least before the dinner, and that of the sitting posture the least before the breakfast. The younger of the two adults was affected by posture to a greater extent than even the children, and at the same time the results were far more uniform than those obtained from the latter. The progression in the decrease as the day advanced was very striking in that case. Thus the increase in the sitting posture was 12, 9, 7·3, 3·5, and in the standing posture 27, 14·6, 12, 10, pulsations per minute as the day advanced. The increasing effect upon the rate of respiration in the children in the evening was quite as great as upon pulsation, whilst the decreasing effect was equally well marked in the respiration of the younger adult, in whom indeed the effect of posture upon the rate of that function was then almost entirely lost.

27. *In Phthisis.*—Table No. 8 represents the results of a similar inquiry made on three males and three females afflicted with phthisis, and extending over a period of six days and nights without intermission, whilst Diagram No. 2 exhibits the same facts in the case of three of the men during two nights and a day.

TABLE No. 8.

AVERAGE HOURLY RATE OF PULSATION AND RESPIRATION IN 6 CONSUMPTIVE CASES THROUGH 6 DAYS AND NIGHTS.

		Midnight.									Break.			Midday.	Din.					Tea.			Sup.		
	Hour	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
3 Men.	Pul.	79·6	74·	74·4	70·4	72·5	69·7	73·9	78·2	77·1	89·5	94·2	90·3	87·7	88·5	91·7	95·8	92·	89·5	92·1	93·8	91·9	89·	85·9	81·4
	Res.	27·6	26·4	25·5	22·9	23·4	22·3	23·6	21·6	18·8	21·3	22·	22·9	23·3	23·1	23·1	24·8	24·6	24·8	23·5	24·	23·7	23·5	22·5	29·2
3 Wom.	Pul.	73·4	68·9	68·5	67·2	67·8	66·7	69·5	72·6	78·8	83·	88·5	87·6	85·7	89·4	92·7	91·6	90·1	90·6	92·5	91·1	90·2	88·5	85·4	81·2
	Res.	31·4	30·3	30·4	29·	29·3	28·7	26·6	25·5	24·2	25·4	26·3	26·3	26·2	29·	26·	28·2	28·9	28·1	30.4	28·6	27·	27·1	27·5	29·2

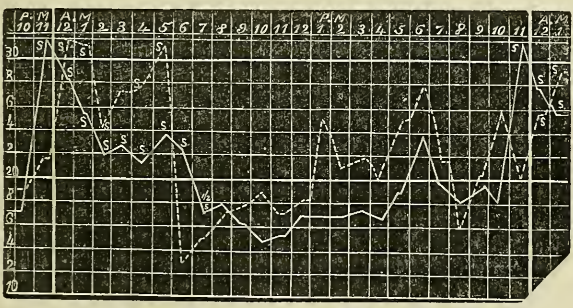
TABLE No. 9.

RATIO OF PULSATIONS TO RESPIRATIONS IN THE TWO SEXES IN PHTHISIS.

									Break.				Din.					Tea.			Sup.		
Hour	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Men . . .	2·8	2·7	2·8	3·	5·1	3·	3·1	3·8	4·3	4·2	4·5	4·1	4·	4·1	4·1	4·4	3·9	3·8	4·1	4·1	4·	3·9	4·	2·8
Women .	2·4	2·4	2·3	2·4	2·4	2·4	2·7	3·	3·5	3·5	3·6	3·3	3·6	3·3	3·7	3·7	3·5	3·5	3·4	3·3	3·5	3·7	3·6	2·9

28. It will be observed by this table and diagram, that there is the same progression in the phenomena as that now recorded in healthy persons, but the extremes are much greater. The total rate of the functions was higher, the difference between the rate in the day and the night was much greater, and oftentimes more than forty pulsations per minute, and consequently an increase of thirty-five to forty pulsations per minute was commonly found after the breakfast. The rate was more uniform, and the depression of the night was greater in the women than in the men. Hence, in reference to pulsation, the only remarkable difference between health and phthisis is the extreme variation in the latter of the night and the day rate, with, as a consequence, the signal increase in the morning and the decrease in the evening; but in reference to respira-

RATE OF RESPIRATION IN TWO CASES THROUGH TWENTY-EIGHT CONSECUTIVE HOURS.



tion, the singular fact was noticed in most of the cases, that the rate increased in the night in a most evident

manner, and fell in the morning on waking, so much sometimes as twelve to fifteen respirations per minute. Table No. 8 shows that on the whole average of the women, the increase in the number of respirations was nearly seven per minute from 10 P.M. to 11 P.M., when they fell asleep, and that there was an average, though a less increase, until 6 or 7 A.M. The average increase in the men was 1·7 per minute from 10 P.M. to 11 P.M., and four per minute at midnight, from which hour the increase gradually subsided.

29. In the individual cases the difference was very striking. Diagram No. 3 well represents a case in which it was marked, and the following table shows with what uniformity this singular circumstance occurred in succeeding nights :—

TABLE No. 10,

SHOWING THE GREAT INCREASE IN THE RATE OF RESPIRATION PER MINUTE AT NIGHT, ON FALLING ASLEEP, AND GREAT DECREASE IN THE MORNING, ON AWAKING.

	P.M.	Mid-night.	A.M.								
Hour	11	12	1	2	3	4	5	6	7	8	9
Date.											
June 18	24	30	26	31	28	28½	27½	29	29½	19	18½
19	21	32	31	24½	27	27½	31	13	14½	17½	18
20	20	26	29	27½	22½	25	24	30	17½	21	21
21	30	30	29	25	28	29	28½	16	18½	17½	19
22	23	28	26	31	28	30	28	29	30	25	22

30. The cause for this remarkable change is not very clear, but it appears to be associated with sleep

rather than with any other influence, for the rate immediately fell on awaking at any hour of the night. Thus, in one case it fell from 47 to 37, and from 33 to 27; and in another from 40 to 22, and from 34 to 22 respirations per minute, on simply awaking between 12 to 3 o'clock A.M. The table in reference to the women might also cause us to consider how far the absence of sunlight might have an influence, for the increase lessened in a clear manner at about 3 A.M., when sunlight began to appear at that period of the year, viz. June, but upon the whole, we do not think that this is the cause of the night increase. In a subsequent inquiry on many persons in the night only, we found this increase occurred in nine out of twenty-seven, whilst in the others the night rate was scarcely changed from that which was found before going to bed.

31. The ratio of the rate of respiration to pulsation was much higher than in health, and this was due to the disproportionate increase in the rate of respiration. (24.)

32. The table, No. 9, exhibits the average ratios of the cases in the two sexes at each hour of the day and night, the ratio being 1 respiration to the following number of pulsations.

33. The ratios were thus higher in the women than in the men. The hour of maximum ratio was from 11 P.M. to 3 A.M., and that of the minimum ratio was from 10 A.M. to 8 P.M., the maximum being found in the night, and the minimum in the day, the con-

trary of the fact recorded in health. The maximum ratio varied from as 1 to 1·4 to as 1 to 3.

34. The effect of sunlight in June was to increase the average rate of pulsation from 6 to 10 per minute, and hence the absence of this agent during the night was a cause of considerable decrease.

35. The two series of facts to which we have now alluded are shown in a clear manner in the Diagrams Nos. 1 and 3, constructed to represent the circle and rays of the clock dial; and it will be at once observed that the largest radii representing the greatest number of pulsations and respirations occur in the day hours, and the shortest, representing the fewest pulsations, are found in the night, except in reference to the respiration in the cases of consumption, in which the conditions are reversed. It will also be observed that there are not any two hours of the day in which the same rate of pulsation and respiration is strictly maintained.

36. The effect of posture[1] corresponded with that recorded in health (25), in so far that the increase in the sitting and standing postures over that in lying was lessened in the evening at 4 P.M. The total effect of posture was greater than in health, and amounted to 8½ pulsations per minute, between lying and sitting, and sitting and standing respectively, or a total increase of 17 pulsations per minute, but in the morning the total average

[1] "Brit. & For. Med. Chir. Review," April, 1856.

increase amounted to 20, and in the evening to only 14 pulsations per minute. There was also less uniformity in the results in the evening than in the morning, and particularly in the sitting and standing postures, and in the evening the extremes recorded were less widely apart. The following table, containing the results of more than 1500 observations made during a month, exhibits the increase in each posture both in the morning and evening, and also records the extremes which were observed in the different cases.

TABLE No. 11.

EFFECT OF POSTURE OVER THE RATE OF PULSATION AND RESPIRATION.

	8 A.M.		4 P.M.	
	PULS.	RESP. Excess over that in the lying posture	PULS.	RESP. Excess over that in the lying posture
Mean rate of all the cases	91·2		98·4	
Lying posture . .	81.7		92·4	
Extremes . . .	55 134		62 138	
Sitting posture . .	91·9	1·8	99·6	·9
Extremes . . .	62 142		70 150	
Standing posture . .	101·8	2·3	106·5	1·1
Extremes . . .	76 162		95 166	

37. It is thus shown that the effect of posture in the afternoon is about half of that observed in the

morning before breakfast. It will be borne in mind that all the cases of phthisis were adults, but with that limitation the variation just described was not materially influenced by age, temperament, lung disease, stature or frequency of the rate of the two functions.

Carbonic Acid expired.

38. The next series of inquiries to which we shall refer is that which indicates the hourly variations in the quantity of carbonic acid evolved by the lungs. The recorded observations under this head are extremely few, and refer in a general manner only to the relation of the day and the night, and the effect of certain foods, exertion, and sunlight.

39. Coathupe[1] and Prout[2] sought only the percentage amount of carbonic acid in a few cubic inches of expired air. The former noticed that the quantity of carbonic acid evolved was,—before breakfast, 4·37; before lunch, 3·9; before dinner, with one pint of wine, 3·92; before tea, 4·17; and after tea, 3·63 and 4·12 per cent. Prout stated that the maximum quantity was generally between 10 A.M. and 2 P.M., and the minimum between 8½ P.M. and 3½ A.M. The minimum was 3.3 per cent. at 3½ A.M., and after that hour the quantity suddenly increased until it was 4·1 per cent. at noon. It thence sank, first quickly and then slowly, to 8½ P. M., when it remained stationary until 3½ A.M.

[1] "Phil. Mag.," vol. iv.

[2] Thomson's "Annals of Philosophy," 1813.

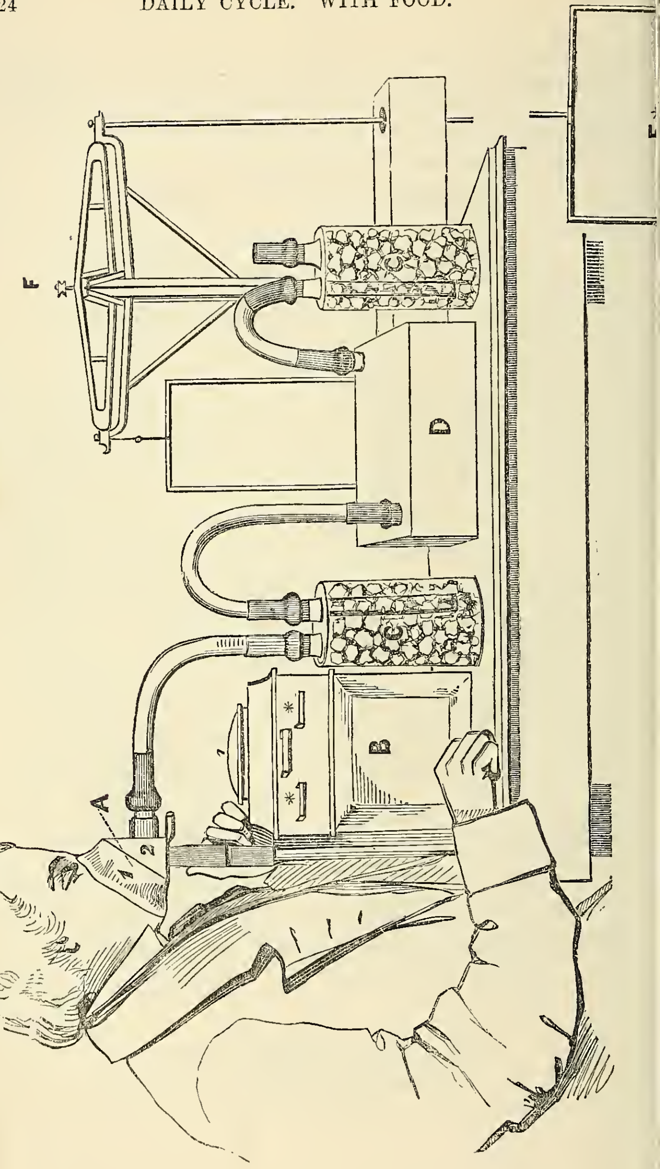
40. As the total quantity of air expired was not ascertained, it is evident that mere per-centage determinations do not aid us in determining the total quantities, and, in fact, are valueless.

41. Prout also found that the increase of the carbonic acid uniformly occurred soon after the beginning of twilight and before sunrise. Scharling[1] states that the proportion of the night to the day varied in his six cases as 1 to 1·225, and as 1 to 1·42.

42. Vierordt,[2] in his most laborious series of inquiries, recorded the hour of his observations, but did not make them with a view to show the variations hour by hour. He found that the difference between the quantity of carbonic acid at 9 A.M. and 8 P.M. was 23 per cent. of the total average. He also showed that the quantity was increased with dinner, and varied with certain special articles of food.

43. We instituted an extended series of inquiries[3] upon four gentlemen æt. 26, 33, 39, and 48 years, during the 18 hours of the working day, and upon ourself in the hours of the night. In two sets of these experiments, the quantity of carbonic acid was collected during ten minutes at the commencement of each hour, and also of each half-hour following the meals; whilst in two others, the whole carbonic acid evolved was collected without intermission, except during a few minutes when food was taken. In the two

1 "Annales de Chimie," 1843.
2 "Physiologie des Athmens," 1845.
3 "Philos. Trans.," 1859.



Dr. E. Smith's Carbonic Acid Apparatus.

Diagram No. 4.

former, the experiments were uniformly made in the sitting posture, but in the latter the sitting or the standing posture was adopted at indicated periods. Hence the former may indicate the condition of absolute and the latter of ordinary rest.

44. The method adopted by us in this branch of inquiry was to collect all the carbonic acid evolved from the lungs by breathing over a solution of caustic potass which occupied the floor of several chambers of a box of gutta percha, and offered so extensive a surface that the whole of the carbonic acid was absorbed during the act of expiration.

45. The following is a detailed description of the apparatus employed, as illustrated by Diagram No. 4:

46. There is, first, a Mask (A) which covers the nose, mouth, and chin, connected by a caoutchouc tube with a small spirometer (B), which measures and registers the air inspired. The mask fits the features so closely that no air can enter the mouth except through the spirometer; and it is composed of tolerably thick sheet lead, lined with sheet India rubber. There are valves so arranged that the expired air cannot pass back into the spirometer, but is directed through other tubes into the analytical apparatus; and, during inspiration, this expired air

---

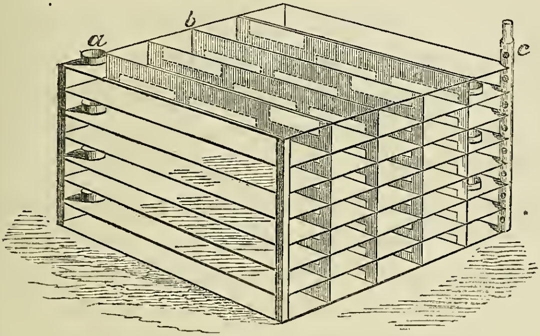
A. Mask. 1. Tolerably thick sheet lead to be moulded to the features; 2. Brass part to support the valves and tubes.
B. Spirometer. 1. Index; ** Loops for knapsack straps.
C C. Desiccators containing sulphuric acid and pumice-stone.
D. Potass-box, with five chambers.
F. Oertling's balance, with long arm and pan. F* to receive the potass-box.

cannot re-enter the mask. Hence all the air which enters the mask is inspired, and none is respired twice. The Spirometer is a small one-light dry gas-meter, of improved manufacture, and registers from one to a million cubic inches. The motor power being the inspiration, it is that of a suction, and not a forcing pump; and hence the spirometer moves in a reverse manner from that which occurs when it is used as a gas-meter. (It will be observed, that it is not a *gas-holder*, such as Hutchinson's spirometer, but a *gas-meter;* and, by frequent testing, it was found to register with uniform accuracy.)

47. There is also an Analytical Apparatus, in which the carbonic acid is absorbed by caustic potass. This has two peculiarities, viz., that the expired air does not pass *into*, but only *over* the solution of potass, so that no impediment is offered to free expiration; and that the whole of the carbonic acid is absorbed during the period of expiration. Hence, when the experiment is over, the carbonic acid can be immediately weighed in one of Oertling's balances, which weigh to the one-hundredth of a grain with seven pounds in each pan; and the experiment can be renewed in a very few minutes. The apparatus consists of three parts: *first*, a desiccator of sulphuric acid and pumice-stone (c), of a capacity of seventy cubic inches, into which the expired air is immediately received from the mask, and from which the dry air is passed into a potass-box (d), which is the *second* and the novel part of the apparatus. This is made of gutta percha, one-

eighth to one-tenth of an inch thick, with dimensions of 12 in. × 12 in. × 5 inches, the edges being well

DRAWING OF A MODEL OF THE POTASH BOX IN THE POSSESSION OF THE ROYAL SOCIETY.



a. Communication between the chambers, defended by a flange.
b. Partitions in each chamber.
c. Two sliding tubes with holes communicating with each chamber, which are closed when the inner tube is half round.

fastened together by the hot iron, and by a sealing of strips of gutta percha melted and fixed upon the joints by the hot iron. There are five chambers, each occupying the whole superficies of the box, and five-eighths of an inch in depth; and, being placed over each other, there is a communication from one to the other by an opening somewhat larger than the area of the trachea. Around this opening, on the upper surface of each floor, is a ring of gutta percha, one-fourth of an inch in depth, to prevent the fluid lying upon each floor from passing through into the chambers beneath. Each chamber is subdivided, by strips

of gutta percha (*b*), into six cells. The strips are fastened by the hot iron to both the floors, and are made imperfect in the lower edge, so as to allow the fluid to pass freely over the whole chamber, and also at the upper edge at each end alternately, so as to permit the column of air to traverse the cells one after another, and therefore in two directions alternately, and at length to be passed through the opening in the floor to the chamber above. There are thus five chambers, having a total superficies of upwards of seven hundred inches, which communicate with each other, into each of which the fluid potass is passed by means of gutta percha tubes three-eighths of an inch in diameter, or by two sliding tubes, as represented in (*c*). Thirty fluid-ounces of solution of caustic potass, of specific gravity 1·27, are introduced, and are found by experiment to absorb upwards of six hundred grains of carbonic acid, without permitting the smallest trace to pass over, as tested by baryta water. The expired air is passed to the bottom chamber by a gutta percha tube, of the size of the trachea; and, having passed through each cell of each chamber in succession, escapes from the upper chamber, and is carried to the third part of the apparatus. The tubes are closed with corks when the potass has been introduced, aud the corks are not removed until the contained potass must be discharged and replaced. The same potass may be allowed to remain in the box for many days; and the box itself, after having been used for more than twelve months,

Carbonic Acid with and without Food

FIG 1

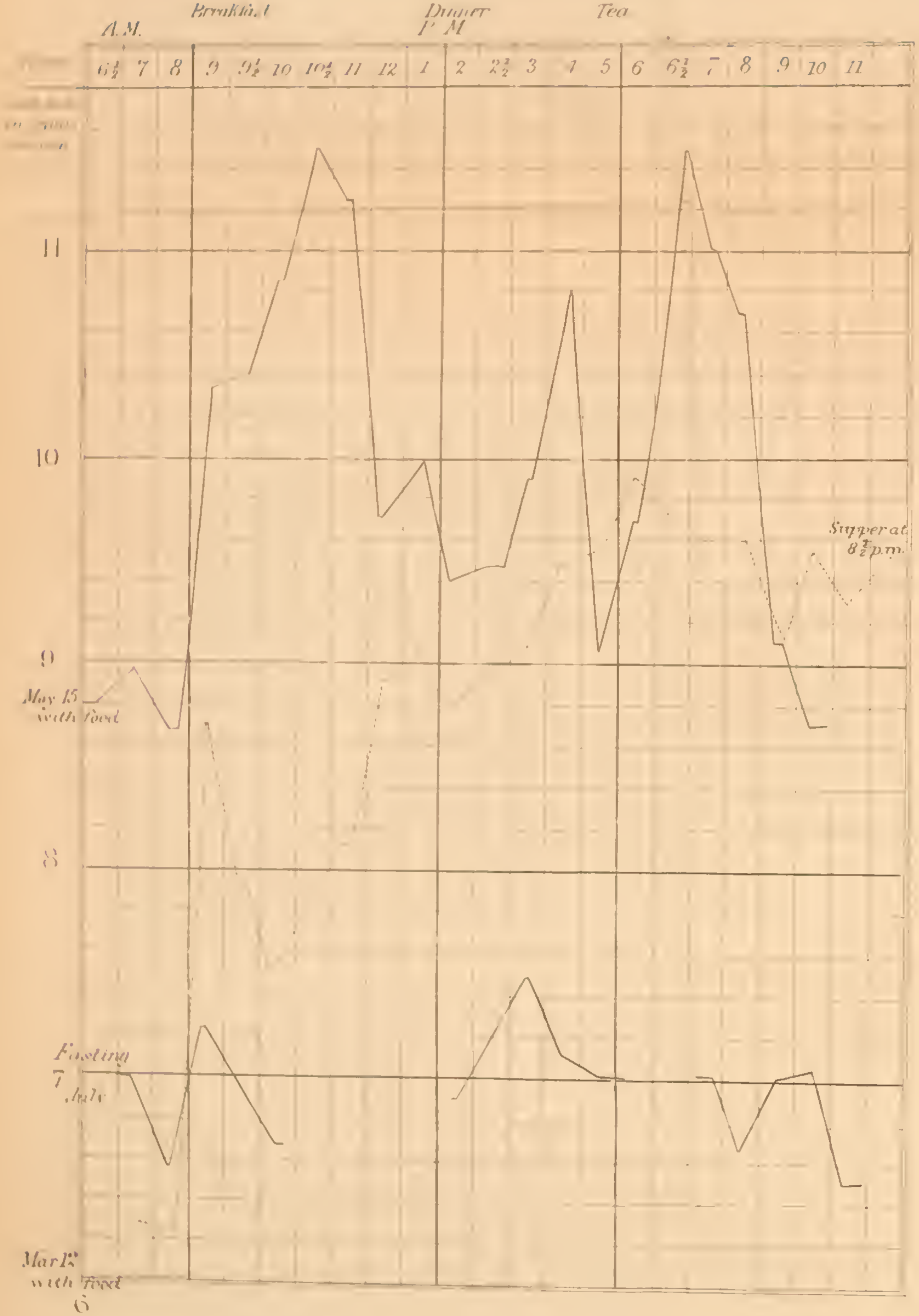


Diagram shewing the quantity of Carbonic Acid evolved during the day with food on two occasions and without food on one occasion.

Carbonic Acid and Temperature

FIG 2

Relation of Temperature & Carbonic Acid on April 13 to 27th 1858.

	Temp:	49°	47·5°	54°	56·5°	58°	60·5°	62·5°	62·6°	63·6°	59·°	58°
Carb: Acid grains per min	Self	9·34	9·46	8·14	8·3	8·4	8·08	8·04	8·76	8·4	8·11	9·3
	Mr Moul		7·7	6·9	7·2	7·	5·4	6·62	5·38	5·12	6·	6·52
	Mr Moul		482	438	441	400	298	394	306	318	392	391

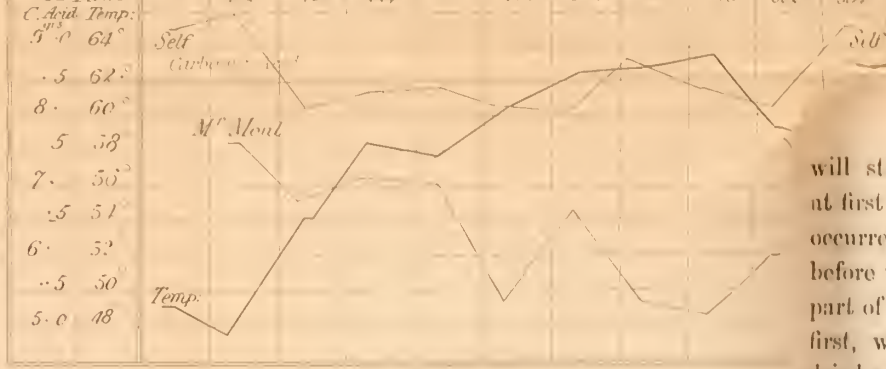


FIG 3.

Relation of Carbonic Acid to Temperature 1858.

	April	14	15	16	20	21	22	23	24	26
	Temp:	47·5°	54·°	58·5°	58·°	60·5°	62·5°	62·6°	63·6	59·
Carb: Acid (in grains per min.) to each degree of Temp:	Self	·2	·15	·142	·141	··133	·128	·14	·132	·157
	Mr M.	·162	·127	·123	·12	·0·1	·10,5	·07	·13	·1
Carb: Acid (in grains per min) lessened with each degree of Temp. above 47·5°	Self		·2	·1	·1	·1	·093	·046	·065	·128
	Mr M		·12	·015	·066	·177	·072	·153	·098	·148

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will still be uninjured by the fluid, provided it was at first very securely made; but, should a leak have occurred, the surface must be neutralised with acid before the hot iron will again secure it. The *third* part of the apparatus is a desiccator (c) similar to the first, which absorbs the watery vapour which the dried expired air had carried off from the fluid potass. The addition to the weight of the first drying apparatus with the mask and tubes gives the amount of vapour in the known volume of expired air, and the increase in weight of the second and third parts of the apparatus gives the amount of carbonic acid in the expired air. When the expired air is passed with the rapidity of ordinary expiration, this apparatus is sufficient; but when the rapidity is increased, as in voluntary efforts or during exertion, it is needful to use a double set. When, during a continuous experiment, it is desirable to weigh the carbonic acid at intervals, this may be effected by having two sets of the apparatus, since one may then be detached from the mask, and another be attached, without the loss of an expiration. The apparatus, including even the balances, is portable, and may be placed in two boxes, and carried to any distance without injury.

48. Table No. 12 shows the amount of carbonic acid evolved per minute during each of the two former series of inquiries upon six persons, and Diagram No. 5, fig. 1, represents the amount evolved by ourself alone in these two inquiries; and all show a striking similarity with the variations in the rate of

TABLE No. 12,

SHOWING THE HOURLY RATE OF EXCRETION OF CARBONIC ACID, IN GRAINS, PER MINUTE, IN SIX MALES, IN THE SITTING POSTURE.

	A.M.		Breakfast.						P.M.	Dinner.					Tea.				Supper.			Midnight.	
Hour	6½	7	8 8½	9	9½	10	10½	11	12	1 1½	2	2½	3	4	5 5½	6	6½	7	8 8½	9	10	11	12
Mar. æt. 26		6·14	6·79	9·14	8·06	8·99		8·21	8·2	7·3	8·06		9·23	7·05	7·67	9·25		8·45	7·83	7·87	7·6	7·7	7·33
May, æt. 33	5·15	5·43	4·58	6·01	7·49	8·32	7·47	6·23	6·73	6·05	6·53	6·74	6·45	6·97	6·78	7·	7·45	7·75	7·65				
Mar. { æt. 38		6·3	6·25	8·7	7·9	7·44		8·16	8·92	8·95	8·8		9·1	9·49	9·57	9·95		9·6	9·59	9·11	9·55	9·38	9·52
May { æt. 38	8·85	8·97	8·68	10·05	10·41	10·89	11·53	11·27	9·72	10·01	9·4	9·5	9·9	10·82	9·02	9·67	11·49	11·	10·72	9·11	8·75		
Mar. { æt. 48			8·15	8·22	11·36	8·95		8·82	9·2	7·65	9·08		8·6	8·75	6·76	8·1		10·1	8·3	7·75	8·35	8·25	7·5
May { æt. 48	7·1	7·34	6·76	7·1	8·49	8·36	8·58	8·11	7·16	7·65	7·55	7·58	9·02	8·48	8·05	8·47	8·66	9·18	9·35	8·26	7·18		
Average of the whole	7·03	6·83	6·83	8·2	8·45	8·82	9·19	8·46	8·32	7·93	7·93	7·97	8·71	8·59	7·97	8·74	9·2	9·39	8·9	8·62	8·29	8·44	7·78

pulsation and respiration already referred to (Diagram No. 2),—so striking, indeed, that the curves might almost be taken to represent both the rate and the quantity.

49. In experiments made to determine the amount evolved under the influence of not very profound sleep, it was found to be 4·88 grains and 4·99 grains per minute, at 1 and 3 A.M.; but we estimated the amount at 4½ grains per minute in profound sleep. Hence, commencing at from 1 to 3 A.M., the period when the lowest amount of carbonic acid is evolved (4·88 and 4·99 grains with sleep, and 5·7 and 5·94 grains when scarcely awake), it was found that there was an increase at about 6 A.M., when it amounted to a little more than 6 grains per minute, and at 7 A.M., after rising, to 7 grains per minute. The effect of the breakfast was to cause a total increase of 2½ to 3 grains per minute, in from one to two hours, followed by a decrease of 1 to 1½ grain per minute before the dinner. There was commonly an increase after dinner of about 1 grain per minute, and usually a decrease from that period to the hour of taking tea; but on some occasions, as on March 12, the quantity remained high until after the tea had been taken. After tea there was again an increase of from 1 to 1½ grain per minute, and the highest point of the day was attained. At about 7 o'clock a fall began to occur, and the decline progressed to the extent of 2 or 3 grains per minute at the hour of bedtime, but sometimes after supper, the quantity remained somewhat elevated

until a later hour. After retiring to rest, at 11 o'clock, the quantity fell steadily until 1 to 3 A.M., when the minimum was attained.

50. Hence there were commonly 4 minima and 3 maxima in the daily quantities of carbonic acid evolved, the former found immediately before each meal (except supper) and during the night, and the latter following each meal. The largest increase commonly followed breakfast and tea, and then the total quantities evolved were nearly identical, whilst there was also a great similarity in the minimum quantities recorded at the end of the intervals between the meals. This variation was due to food, but there was a low point below which the quantity did not fall. The highest amount of this variation was from $\frac{1}{3}$ to $\frac{1}{4}$ of the whole quantity evolved. There was not any hour of the day in which the evolution of carbonic acid was stationary, except in the hours immediately preceding the breakfast.

51. The minimum and maximum quantities of carbonic acid evolved on each day per minute were very diverse in the four sets of inquiries, as is shown in

TABLE No. 13.

Carbonic Acid—grs. per Minute.					
	Min.	Max.		Min.	Max.
Self, æt. 38	6·25	9·59	Mr. Moul, æt. 48	6.76	11.56
	8·68	11·53		6·76	9·35
	7·81	11	Dr. Murie, æt. 28	6·14	9·25
	6·96	13·3	Prof. Frankland, æt. 33	4·58	8·32

The total being 6·74 and 10·43 grains, and the extreme 4·58 and 13·3 grains per minute.

The Quantity of Air inspired.

52. This was determined in three of the experiments just recorded by the aid of a spirometer, which registered from one to one million cubic inches of air inspired, and the quantities are recorded with those of carbonic acid in the tables published in the "Phil. Trans." There was a general concurrence in the progression of the quantities both of the carbonic acid expired and the air inspired, so that it is not necessary to give any special description of the latter. The quantities at different hours varied as largely as those of the carbonic acid above recorded, and the maxima and minima were as follows, in cubic inches per min.:

TABLE No. 14.

Air inspired—Cub. in. per Minute.		
	Max.	Min.
Self, æt. 38	710	429
	597	464
Mr. Moul, æt. 48	581	402
	469	391
Prof. Frankland, F.R.S., æt. 33	420	219

53. The proportion of the carbonic acid to the quantity of air inspired at rest was 1 grain to 58 cubic inches; 54·8 cubic inches; 58·5 cubic inches; and

54·7 cubic inches, in ourself, Mr. Moul, Dr. Murie, and Prof. Frankland, in order.

54. Hence in these different directions, and in the various series of inquiries, results of very close uniformity were obtained, all agreeing in the marked difference in the vital actions in the day and the night, the great and rapid influence of food, the temporary effect of food, and the varying amount of action due to the different meals.

Urea evolved.

55. This important branch of inquiry has been more widely investigated than any other to which we shall have to invite attention, probably because of the ease with which the analyses may now be made, and the opportunity which every man has of pursuing the inquiries upon his own system.

56. It has been affirmed that because urea is the product of food and exertion, and those conditions occur chiefly in the later period of the day,[1] the amount of urea evolved is greatest in the afternoon and evening, and yet sinks during the night. Such, at least, are the results of Kaupp's[2] inquiries. Dr. Draper, also, observes that the amount of urea was reduced at night, but the quantity of urine was nearly equal in the two parts of the twenty-four hours. In such inquiries it is evident that the hours should be defined which indicate the day and night, and also

[1] Parkes on the Urine, p. 96.

[2] Vierordt's Archives, 1856.

that the nature and period of the last meal will influence the amount of urine and urea emitted after it.

57. There have not been any experiments especially directed to determine the hourly variations in the urea and urine, and hence we find the results hitherto obtained arranged in the general manner just indicated.

58. We commenced a series of inquiries upon ourself in the beginning of 1860, and continued them on nearly every day until March, 1861, with a view to show the variations of urea and urine, hour by hour, under noted conditions. This resulted in the determination of the total quantities of the twenty-four hours—of the day and night separately—of the quantity secreted before breakfast, after the night urine had been passed—of the quantities to 12 mid-day, and during each two hours in the afternoon—and, lastly, of the quantity evolved at each quarter of an hour after the breakfast and an early dinner on different days. At the same time the fluid and solid egesta were duly determined.

59. The following table (No. 15) gives the amount of urea and water evolved per hour at each quarter of an hour, from the breakfast of twenty ounces of coffee with bread and bacon, until $1\frac{3}{4}$ P.M., and also the quantity evolved on another day from $1\frac{1}{4}$ P.M. to $3\frac{1}{2}$ P.M., after ten ounces of coffee and bread and butter had been taken at 1·20 P.M.

60. In reference to the first part of the table, we may remark that the basis quantity on that day, or

TABLE No. 15,

SHOWING THE HOURLY EXCRETION OF UREA AND URINARY WATER AT EACH QUARTER OF AN HOUR.

	A.M.						P.M.														
Hour	10½	10¾	11	11¼	11½	11¾	12	12¼	12½	12¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½
Dec. 17.																					
Urea, grs.	29·64	24·8	27·1	26·65	27·8	35·2	33·6	36	40	54·6	26	24	24	25							
Water, ozs.	7.7	7·37	8·34	8·2	9·6	12·8	11·6	12	9·9	13·5	6·5	4·6	6	4·6							
Dec. 18.																					
Urea, grs.												23·7	22	25·1	20·8	20·5	24·26	22·8	23·28	28·8	25
Water, ozs.												4·4	3·8	4·5	4·2	3·12	3·37	3·	3·	3·8	5·4

TABLE No. 16,

SHOWING THE AMOUNT OF UREA AND URINARY WATER EVOLVED PER HOUR.

	12.0 P.M. to	Break. A.M.				P.M.		Din.			Tea.			Coffee.			A.M.
	8.41 A.M.	9	10	11	12	1	2	3	4	6	7	8	9	10	11	12	9
Mar. 2.																	
Urea, grs, .	15·68	10.68	20·67	31·4	25·8	28·	26·	24·3	17·8	20·7	17·6	25·	28·4	29·2	23·9	20·2	19·5
Water, ozs. .	1·	1·03	2·05	7·5	4·1	11·1	5·05	3·35	1·75	1·45	1·15	1·95	2·6	2·87	2·23	1·33	1·44

that which was passed after the night and before the breakfast, was hourly 1·32 oz. of water, and 19 grains of urea. Hence there was a progressive increase during three hours and a half after the breakfast, when the maximum of 54·6 grains of urea per hour, or nearly three times the basis quantity, was evolved in the examination. After this the quantity subsided to 23 grains per hour, when the series terminated.

61. In the second series the basis quantities were 1·1 oz. of urine, and 14·3 grains of urea hourly, and at 1·15, before the food was taken, they were 4·4 oz. and 23·7 grains respectively. The increase was very small, for at 3.15 P.M., or in one hour and three quarters, the quantity was only 28·8 grains, and the quantity at the termination was 25 grains per hour. This shows an enormous advantage in favour of the morning emissions.

62. A third series of inquiries was undertaken on March 2nd, when the system was eliminating a large quantity of urea and when an unusually large dinner was eaten at 3 P.M. The state of the health was not quite perfect, as on the following day it was found necessary to take aperient medicines. The preceding table, No. 16, contains the results of the inquiry made at each hour from 8·41 A.M. until midnight.

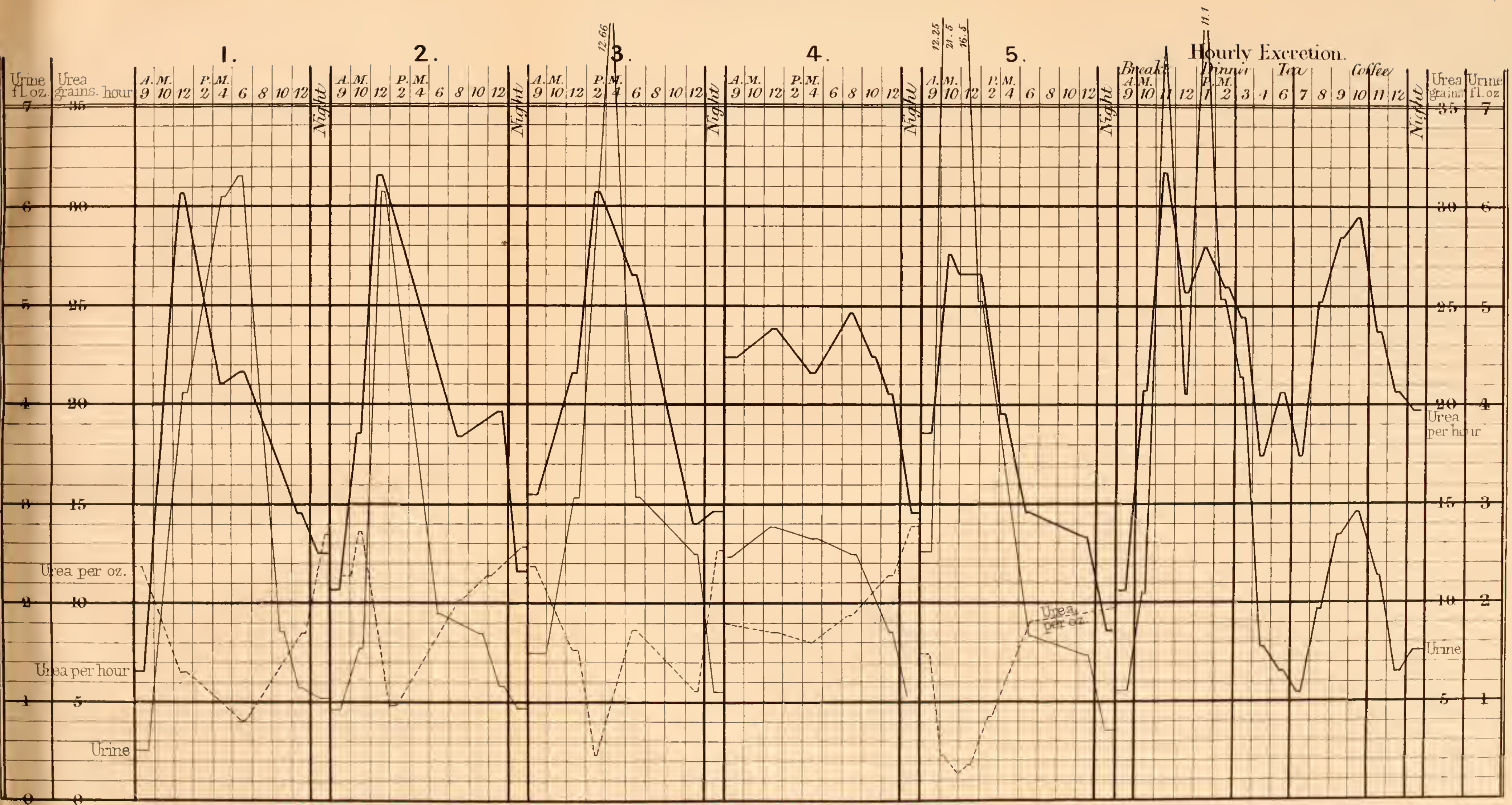
63. On this day 20 ounces of fluid were taken at $9\frac{1}{4}$ A.M., 18 ounces at 3 P.M., 13 ounces at 6·10 P.M., and 17 ounces at $10\frac{3}{4}$ P.M., and the total quantity of solid food eaten was $40\frac{3}{4}$ ounces, of which 9 ounces was bacon

and other animal food. The total ingesta weighed $108\frac{3}{4}$ ounces. It will be observed that the largest quantity of urea per hour was eliminated at 11 A.M., when it was thrice that evolved before the breakfast had been taken. There was no increase, but, on the contrary, a diminution in the quantity evolved between the hours of dinner and tea. The most noticeable circumstance was the large increase which followed the tea, by which the quantity at 10 P.M. nearly approached the maximum at 11 A.M. The quantity eliminated throughout the following night was much greater than that emitted in the preceding night. More food had been taken during the day than was required by the wants of the system, but the unusual elimination of urea at 9 and 10 P.M. was clearly also associated with an unusually large egestion of urinary water.

64. Diagram No. 6 shows the progression in the quantity of urea evolved per hour, and in that found in each ounce of urine during the day until midnight, and also during the night. There was some variation in the absolute amount evolved, according to the nature and amount of food, the temperature, and period of the year, but the progression was tolerably uniform under the ordinary conditions of the system.

65. The amount of urea evolved immediately before breakfast was not uniform with that produced through the night, being sometimes a little above, and at others a little below that quantity, but both agreed in the fact that at these periods there was the

Urea & Urinary Water (Pages 38 & 43.)



least quantity evolved per hour. Immediately after breakfast, consisting of one pint of coffee with bacon and bread, there was a most rapid increase, so that between 9 and 12 A.M. the quantity increased from 10 or 15 grains to 25 or 30 grains per hour, and from 12 to about 2 o'clock, the greatest amount of the day was evolved. At 4 or 6 P.M. the quantity had declined 5 to 10 grains per hour, and the decline commonly continued progressively until the night minimum was attained, but sometimes the quantity remained high until late in the evening. Hence the greatest amount of urea evolved per hour is in the early part of the day, and as the day advances the amount declines, whilst the lowest amount of the 24 hours occurs during the night hours. The maximum period of the day is about, or soon after, midday, and the ascent and descent in the quantity are very rapid. A second increase occurred at 6 to 8 P.M.

66. In these experiments it is important to bear in mind that the breakfast was a good one, and was followed by a moderate and simple dinner, without wine, at about 2 P.M., 14 oz. of tea at 5 or 6 P.M., and 15 oz. coffee, each with bread and butter, at 9 or 10 P.M. Hence, it was evident that the larger evolution of urea neither corresponded with the amount of nitrogenous matter taken in the previous meal, nor with the exertion made, but rather with the degree of activity of the vital processes. When, however, an unusually large or unusually late dinner was taken, with more than an ordinary quantity of wine, the proportionate

amount of night urea was considerably increased, and the increase was carried on to the following day.

67. When the food and fluid are fairly distributed over the day, as is the case with the masses of the people in all countries, there can be no doubt that the largest hourly excretion of urea occurs before 2 P.M., and thenceforward there is a slow but not uniform diminution to the minimum of the night.

68. If, however, the aim be to show the amount of urea which follows a meal, the result will differ and vary according to the interval between the meals and the nature of the meals, but this is of little value, since, with prolonged duration between meals, we obtain a larger amount of urea due to the necessary vital processes of life, and almost apart from the food which may have been taken.

69. The quantity of urea evolved in each ounce of urine varies with the quantity of water evolved, and Diagram No. 6 shows that the quantity per ounce is the inverse of the quantity per hour. Thus, in the morning hours, with sudden and great increase of the urea per hour, there is a great decrease of that substance per ounce, and as the day advances, the quantity per ounce increases as the quantity per hour decreases. The opposition of the two sets of curves is most striking, and it not uncommonly occurs that the hour of highest elimination of urine is that of the smallest quantity of urea per ounce.

70. There are some circumstances connected with the days from which Diagram 6 has been compiled

which merit attention, and which illustrate conditions to which we have already, or shall hereafter have occasion to refer.

71. Figs. 1, 2, 3, 4 are derived from consecutive days in February. The three former exhibit a similarity of the most striking kind, whilst the fourth shows much dissimilarity. On each of the three first days, the usual breakfast of 22 oz. of coffee was taken, but in fig. No. 1, coffee and bread and butter were taken instead of dinner at 1½ P.M. Meat was eaten with the tea at 7 P.M., and a little jelly at 11 P.M. On the following day (fig. 2), the usual early dinner was taken, and a rather large amount of bacon was eaten with tea at 9½ P.M. On the third day (fig. 3), 10 oz. of porter were added to the dinner, and at about 11½ P.M., 8 oz. of champagne and other wines and some unusual kinds of food were eaten. Bearing these facts in mind we notice the comparatively high amount of urea evolved on the second day in the evening (fig. 2), after the bacon had been eaten, and the slightly increased elimination of urea during the night, as shown in fig. 3, after the wine had been taken.

72. On the day represented in fig. 4, only 14 oz. of coffee were taken at breakfast, whilst 18 oz. of strong beef tea were drank at 2 P.M., and in consequence of being unwell, no meat could be taken after that hour. The figure shows that there was an unusual discharge of urea in the early morning, viz., 22·3 grains, instead of 10 or 15 grains per hour,

due to the digestion of unusual food on the previous night, and although there was no rapid increase after the breakfast, the quantity was high until midnight, and indeed during the following night. It will also be observed that on this day the amount of urea in each ounce of urine was increased.

73. Fig. 5 represents the effect of taking 8 oz. of cold water alone at $8\frac{1}{2}$, $9\frac{1}{2}$, and $10\frac{1}{2}$ A.M., and omitting the breakfast until mid-day. The amount of urea emitted from 9 A.M. to mid-day was very considerable, viz., $26\frac{1}{2}$ grains per minute, whilst the amount per ounce of urine was very small, but at night the hourly excretion was reduced to so low a point as 8·2 grains per minute. The former effect was due to the ingestion of the water, and the latter to the diminished nutriment which the loss of a meal induced.

Urinary Water.

74. The quantity of water eliminated by the kidneys varies very greatly in the cycle of the twenty-four hours, but, as will be inferred from the above statements, it is found to correspond somewhat with the quantity of urea evolved per hour. Thus whilst the quantity of urea found in each ounce of water usually varies inversely as the quantity of water, the total quantity evolved per hour is increased when there is an increase in the quantity of water evolved. This is a parallel fact with that found in the evolution of carbonic acid, viz., that with an unusually large voluntary inspiration of air, the quantity of carbonic acid

evolved in each 100 cubic inches of air is lessened, but the total quantity evolved in a given time is increased.

75. We have inserted in Diagram No. 6 a line showing the hourly excretion of water on the days therein referred to, and it will be noticed how closely parallel in direction are the lines representing the elimination of urea and water per hour. The contrast between the figs. 3 and 4 illustrates two important facts, viz., the dependence of the elimination of urea upon the elimination of water, and the compensating power which exists in the system; so that if there be an unusual increase in the quantity of urine eliminated on any day, we may safely affirm that there was an unusual decrease on the day or days immediately preceding, or there will be an unusual decrease on the day or days immediately succeeding. In fig. 3 the quantity of water eliminated at the maximum was 12·66 ounces per hour, and 67·62 ounces in the twenty-four hours, whilst in the day preceding the total quantity was 44·4 ounces, and in that succeeding (fig. 4) it was 45·15 ounces. On the latter day the maximum quantity per hour was only 2·72 ounces.

76. Fig. 5 representing the day on which water was drank in the absence of breakfast, the quantity of urine emitted between 8½ and 11½ o'clock A.M. was no less than 50·25 ounces, or at a maximum rate of 21·5 ounces per hour at 10½ A.M.

77. It would be possible to illustrate the facts now under consideration to almost any extent, but it is

not necessary for the purposes of this work to say more than that, whilst there is much diversity in the amount of water emitted, figs. 1, 2, and 3 may be regarded as fair representations of the quantity under the conditions in which we lived. In those conditions the quantity of water evolved per hour is the least during the night, and commonly there is a small increase before the breakfast in the morning. After the breakfast there is a rapid increase, so that from 1½ ounce per hour at 8½ A.M. there will be 4 or 6 ounces per hour at 10½ A.M. and 6 to 8 ounces per hour at midday. From about this period there is a decrease, so that at 4 P.M the quantity is reduced to 4 ounces per hour, at 7 or 8 P.M. to 2 or 3 ounces per hour, at 11 P.M. to less than 2 ounces, and from that point it falls to the lowest period of the twenty-four hours. It is, however, highly probable that if only a small quantity of fluid were taken at the usual breakfast hour, the excessive elimination of water before midday would not occur, and a more uniform distribution over the middle hours of the day would result. But when a large amount of fluid is taken at night, it commonly happens that no corresponding increase in the quantity of urine occurs on that day, but the fluid is retained, and is emitted on the following day. Tables Nos. 15 & 16.

78. Having thus glanced at the conditions of the elimination of urea and water by the kidneys, we cannot but be impressed with the fact that they obey similar laws in reference to their hourly excretion,

and that, however much both may depend upon other agencies, one of these is in great part dependent upon the other. Hence the elimination of urea is a fact apart from its production.

PHENOMENA DURING FASTING.

79. So far we have referred to inquiries made under natural conditions, but before concluding this abstract of scientific inquiries, we will glance at the conditions which are found in the absence of food.

80. There has been but little recorded under this head in reference to man, except the general statement that all the vital processes were lessened when food was greatly reduced in quantity. Numerous experiments have been made with entire abstinence from food upon dogs and other animals for lengthened periods, but the period of total fasting in experiments upon man has been very short. When the food was greatly reduced, it sometimes occurred that the diminution in the amount of urea evolved was not immediate, as in the observations of Beigel, but usually the diminution both in the carbonic acid and urea was immediate and continuous. When the quantity of fluid taken was much reduced, as in the investigations of Mosler,[1] the amount of urea evolved was very much lessened, and when it was again given in full quantity, it was yet some time before the usual amount of urea was excreted—facts showing the im-

[1] Archiv. des Vereins, &c. Band. iii. p. 398.

portance of fluid in either producing or eliminating urea.

81. Our own investigations under this head will now be recorded in the order which we pursued in our preceding remarks.

Rate of Pulsation and Respiration during Fasting.

82. The two children and the three adults referred to at 12 fasted, the former from $7\frac{1}{2}$ P.M. until $2\frac{1}{2}$ P.M., and the latter from $7\frac{1}{2}$ P.M. to $6\frac{1}{2}$ P.M on the following day—that is, to say, for nineteen and twenty-three hours respectively. No marked uneasiness or want was experienced, except at the breakfast hour, but a sense of weariness occurred, and perhaps a feeling of impatience at the frequent repetition of the experiments. In this inquiry the rate of pulsation and respiration was determined in each case in the three postures of lying, sitting, and standing, and the results obtained in the lying posture are given in Table No. 17, for comparison with those recorded in Table No. 2, whilst those in reference to the child æt. $8\frac{1}{2}$ are added in the faintly dotted line to Diagram No. 1.

83. It will be observed that the rate of both functions remained low at the breakfast hour, or the period when it usually rose with food, and indeed in cases æt. $8\frac{1}{2}$ and 33 it fell from the rate observed before the breakfast hour. The diminution in the rate of pulsation during the whole period of fasting from that which ordinarily occurred with food, was from 8·8 to 13·8 pulsations per minute in the different cases, and

TABLE No. 17,

Showing the Rate of Pulsation and Respiration per Minute in Five Persons, in the Lying Posture, during a Prolonged Fast, from 7½ p.m. on the previous Night.

		A.M.				P.M.		Dinner.				Dinner.		
	Hour	8	9	10	11	12	1	2	3	4	5	6	7	8
Pulsation.	Æt. 6	88	82	90	89	90	84	92	108	100	112	90	102	90
	8½	83	72	72	76	70	80	84	96	98	89	86	82	88
	33	76	60	56	59	56	60	61	64	59	58	56	68	74
	36	76	72	70	72	70	68	68	67	68	68	68	73	73
	39	54	52	56	54	54	54	55	56	56	54	56	66	68
Respiration.	Æt. 6	19	22½	22	24	24½	23½	24½	23	25	24½	22	24½	21
	8½	22	21	24½	22	23	23	25	22½	22	25	22½	21½	21
	33	18	16	17	18½	17	18½	17½	18	18	17	16½	18½	18½
	36	16	17	17½	17½	19	18½	19½	20	19	20	18½	20	19
	39	13½	15	16	16½	16	16	15	16	16	17	17	17½	18

10 on the whole average. The proportionate diminution in the rate of respiration was somewhat less, but it varied from 4 to 3 respirations per minute.

84. After the large depression observed at the hour at which breakfast was usually taken, a low and tolerably uniform rate of the functions was maintained, but there were two periods at which an elevation of the rate occurred, which it is desirable to notice. The first occurred between 9 and 10, or 10 and 11 A.M., in the different cases, and the second between 12 and 3 P.M., viz., at the periods when there was usually an increase with food although as above-mentioned no food had been taken, and no external cause of excitement had occurred.

85. It has just been stated that on the whole average the rate of the functions was lessened during the fast, but when the fast had ceased and a full meal had been taken, the rate increased in the evening so much beyond the usual rate at that period, that as the total average of the 24 hours the results were nearly the same in both children and one adult as if no fast had occurred, as is shown in the following table:—

TABLE No. 18,

SHOWING THE AVERAGE RATE OF PULSATION, FROM 8 A.M. to 8 P.M., INCLUSIVE, WITH ORDINARY MEALS, CONTRASTED WITH THE RATE WITH ONLY ONE MEAL AFTER A PROLONGED FAST.

Æt. years	6	8½	33	36	39
Ordinary food...............	96·5	83·2	73·9	77·2	60·7
One meal	93·1	82·7	62·	70·2	56·5

86. A similar, but perhaps more striking illustration of this valuable power of compensation was elicited in connexion with an inquiry into the influence of a short fast on a number of consumptive cases of both sexes, by which it was found that the short fast tended to produce even a slight increase on the total average pulsation of the whole day.

87. In another series of inquiries, prosecuted in July, in which we fasted 39 hours from the evening, with only a moderate breakfast on the following morning, the rate of pulsation gradually and progressively fell throughout the afternoon of the first day (after the breakfast) from 71 per minute at 1 P.M., and 67 at 4 P.M., to 58 per minute at 9, 10, and 11 P.M.; and during that period the pulse was first feeble and then very soft. On the following morning the rate again rose to 71, but again fell to 66 per minute; and at 9 and 10 P.M. the rate of respiration in like manner declined from 12 to 10 per minute during the first day, but on the following morning remained the same as had been observed on the previous night.

88. A third series of experiments was prosecuted in January, 1860, on ourself, and was continued for 29¾ hours. No breakfast was taken, but 8 oz. of water were drank at 8¼ A.M., 12¾, and 5½ P.M., and 6 oz. at 8¾ P.M. The rate of pulsation and respiration varied from that recorded in the foregoing fast, inasmuch as there was an increased rate of pulsation observed after each supply of water, as is shown in the following table:—

TABLE No. 19.

SHOWING THE INFLUENCE OF THE INGESTION OF WATER OVER THE RATE OF PULSATION AND RESPIRATION.

	Water.				Water.				Water.		Water.	
Hour	9	10	11	12	2	3	4	5		7½	10	10½
Pulsation	67	64	64	69	72	64	60	64	71	70	73	72
Respiration	14			12½	13			13		13½	13½	

89. These rates were observed in the sitting posture. Hence, during a prolonged fast, the rate of both functions is greatly reduced, and that of pulsation progressively declines until sleep arrests the fall or food increases pulsation. The effect of drinking water is very striking, but of short duration. The influence upon the rate of respiration is less than that upon the rate of pulsation, and the rate is more uniform throughout the period. The influence upon the rate of both functions of the recurrent periods of meals, but whilst food is yet absent, is instructive, as is also that of the compensating power which the system possesses of increasing the vital actions after a fast.

Carbonic Acid evolved during Fasting.

90. The quantity of carbonic acid evolved during fasting has been determined by us in the two series of experiments referred to in the former section which took place in July and January, but we shall only refer to the former. The fast extended from 9½ A.M. on July 6 to mid-day on July 7, or a duration of 39 hours,

with only one meal intervening, and was made upon ourself alone. As a moderate supper had been taken at 9 P.M., we slept well during the night, and did not attempt to make any observations, neither was the following night's rest disturbed by experiments, but as we had then great difficulty in keeping the body warm, it is probable that the sleep was not quite natural. During this long period there was no abnormal sensation of want, but there was a very marked feeling of tameness, and on the last morning we had temporary headaches of a throbbing and distressing character. Nothing, however, occurred to disturb the general course of the inquiry, and the results may reasonably lead to the inference that no disturbance did take place.

91. Nothing could exceed the extreme uniformity in the vital actions during that period, for the quantity of carbonic acid evolved per minute was almost absolutely the same at 2, 4, 5, 6, 7, 9, and 10 o'clock on the first day, and at 7 o'clock on the following morning. The extreme quantities were 6·52 and 7·44 grains per minute, a difference of less than 1 grain per minute throughout the whole working day. The total average of the 24 hours was 6·61 grains per minute, and the total loss from that of a day with ordinary food was 25 per cent.; but the whole amount of carbon evolved was yet 5·923 (nearly 6 oz.) avoirdupois, an amount equal to that contained in 20 oz. of bread or 7½ oz. of fat. Hence the changes in the evolution of carbonic acid observed during fasting are

perhaps the least of any which occur in the living body. There was evidence of the same attempt at periodical variation which was observed in the first series of inquiries on pulsation and respiration, viz. the tendency to an increase in quantity at the period when an increase did usually occur with food. This is represented in the lower part of Diagram No. 5, fig. 1, where, in addition to the hourly quantity recorded during the period, it may be seen that with a decrease immediately before the hour of breakfast, there was an increase immediately after that hour, and a second and more marked increase at 3 P.M. after the usual dinner hour.

Vapour exhaled by the lungs.

92. The progression in the quantities of vapour exhaled by the lungs in the last-mentioned experiment followed that of pulsation, for whilst it was 2·26 grains per minute at 1 P.M. on the first day, it fell progressively to 1·74 and 1·8 at 8, 9, and 10 P.M., but on the following morning it again increased to 2 grains and 2·2 grains per minute. As our experiments in the ordinary state of the system at rest proved that the quantity normally evolved is from 3 grains to 3·4 grains per minute, the total average diminution was 37 per cent.

Quantity of air inspired per minute and at each inspiration whilst fasting.

93. The quantity of air inspired was determined by the foregoing experiment in reference to the evolution

TABLE No. 20,

SHOWING THE QUANTITY OF AIR INSPIRED PER HOUR AND AT EACH INSPIRATION. FASTING.

	P.M. July 6.											A.M. July 7.				
Hour	1	2	3	4	5	6	7	8	9	10	11	7	8	9	10	11
Cubic Inches per Minute	396	369	368	360	399	364	375	359	360	359	341	369	357	369	373	348
Cubic Inches each Inspiration	33	31·8	33	32·7	33·2	31·3	32·9	33·5	33·6	33·6	33	34·1	33·6	35·4	36·5	33·5

TABLE No. 21,

SHOWING THE EFFECT OF WATER INGESTED OVER THE EXCRETION OF UREA AND URINARY WATER IN THE ABSENCE OF SOLID FOOD.

	A.M. Water.				P.M. Water.							
Hour	7.13 to 8.1	9	10	11.10	12	1	2.15	3	4	5¼	8¾	2½
										Water.		P.M. Water.
Urea per Hour, grs.	7·79	20·48	34·5	20·8	17·85	18·72	15·6	14	13·5	5·3	21·6	7·49
Urine per Hour, oz.	·812	3·2	11·5	6·94	7·44	5·2	10·4	2·93	2·5	1·36	2·57	1·39

of carbonic acid on July 6 (90), and the quantities at each hour are recorded in the preceding table, No. 20.

94. This table shows that the extreme quantities of air inspired per minute were 399 cubic inches and 341 cubic inches, but the volume was between 350 cubic inches and 370 cubic inches in nearly all the observations, and thus there was great uniformity throughout the day. It may, however, be remarked that the first record was due doubtless to the remaining influence of the breakfast, which had been taken at 8½ A.M., and the last record of the same day, which was the least in the series, indicated the fall which always occurs late at night, whilst the increase which was found after the night's rest comports with the observations already recorded in reference to the other subjects of inquiry.

95. The proportion of the weight of carbonic acid expired to the volume of air inspired at rest was greater during fasting than with ordinary food (53), viz., 1 grain to 52·5 cubic inches, and this may be accepted as the standard relation of the two. With food the proportion was reduced to 1 grain to 58 cubic inches, but with exertion it was increased to 1 grain to 44·1 cubic inches when walking at two miles per hour, and 1 grain to 39·7 cubic inches when walking at three miles per hour.

96. The depth of inspiration was uniform in even a greater degree and did not decrease at night, but it increased somewhat on the following morning after the fast had endured nearly 24 hours.

97. Hence on a review of the preceding sections we observe that whilst the daily cycle of changes during fasting in the carbonic acid expired and air inspired are reduced almost to a nullity, there is a progressive decrease in the rate of pulsation and respiration and in the quantity of vapour evolved by the lungs, but in all these points of inquiry alike there is a lower condition existing in the night than the day.

Urea and urinary water evolved during entire fasting from solids only.

98. The quantity of urea and urine evolved under these conditions was ascertained upon ourself in the experiment in October, in which no solid food was taken from the supper, during a period of 29½ hours, but 30 ounces of water were drank at four periods of the day (89.)

99. In this experiment the hourly variations in the excretion of urea followed precisely the same course as that observed when food had been taken, and no remarkable diminution in the quantity evolved was noticed until the night, at which period the quantity was perhaps somewhat reduced. The preceding Table, No. 21, shows the progression in the quantities of urea recorded at each hour.

100. From this table we learn that at 8 A.M. the amount of urea evolved per hour was 7·79 grains, but at 9 it had increased to 20·48 grains and at 10 to 34·5 grains per hour. It then fell to 20·82 grains per hour

at 11 o'clock, to 18 at 12 and 1 o'clock, and thenceforward fell to 15, 14, and 13 grains, and finally to 7·5 grains in the night hours.

101. The quantity of water evolved per hour was ·812 ounces at 8 o'clock; 3·2 ounces at 9; 11·5 ounces at 10; 7 ounces at 11 and 7½ at 12 o'clock. At 2 it was increased to 10½ ounces, but thenceforward it fell to 3 and 2½ ounces, and finally in the night it was 1·4 ounce per hour. Thus in the morning there was a maximum increase in the excretion of water of 14 times as much per hour at 10 o'clock as there had been at 8 o'clock, but with the exception that the amount evolved in the morning was perhaps greater, and that in the afternoon certainly less. There was no marked variation from the progression observed in the ordinary conditions of food.

102. It is especially to be remarked how great was the influence of the water drank over the excretion both of the urea and the urine. In reference to increase this was particularly seen after the first quantity in the morning and the third quantity at 5¼ P.M., when the amount of urea was increased more than fourfold and the urine to the same degree in the morning and to double the amount in the afternoon. No increase followed the quantity which was taken at mid-day. In reference to decrease we are struck with the diminution which occurred just before the third quantity of water was taken and which indicated to how low a point the quantity of urea would have fallen if water had been longer withheld. The final

diminution at the end of the day is in accord with all our inquiries on vital actions.

103. The total amount of urine passed in $18\frac{1}{2}$ hours was $70\frac{1}{2}$ ounces, or $40\frac{1}{2}$ ounces more than the quantity injected. Hence the evolution of water is increased by such a fast as this, whilst the progression in the hourly quantities is much the same as when ordinary food is taken.

DAILY CYCLE.

CHAPTER II.

APPLICATION TO HEALTH AND DISEASE.

104. In the foregoing pages we have entered into a scientific analysis of the daily routine of the system with an extent and minuteness sufficient for the object which we had in view, and with the result, we trust, of having brought down our knowledge upon this subject to the latest moment.

105. We shall now proceed to utilize these results of scientific research and to ascertain in what manner we may use them as guides for daily practice, or as aids in our search to explain well-known phenomena, and to add to them such additional facts of the same nature as the subjects to be now discussed may require. We desire, moreover, to enter into so much detail as may enable us to apply these results as widely as possible to the preservation of health and the cure of disease.

106. The first questions which call for attention arrange themselves under the general head of the assimilative process, and enable us to point out the

conditions which occur in the function of nutrition at the various periods of the day.

THE ASSIMILATIVE PROCESS.

107. It has been abundantly shown that there is more vital action proceeding at one part of the day than at another. The very great effect of the breakfast, as shown both by the great increase in the rate of pulsation and respiration, and in the elimination of urea before midday, proves incontestably that the morning period is that of the greatest vital action; whilst, as the day advances, the food taken at the different meals does not cause an equal increase in the rate of the functions, and the amount of urea is usually lessened hour by hour. The results of all our inquiries seem so decided upon this point, that we are justified in regarding them as the exponents of natural laws in the conditions as to meals in which the experiments were made, and as indications that this is the condition most conducive to health. We will now proceed to consider this subject in detail.

108. *In the morning hours, digestion and assimilation are performed in their most natural and therefore most healthful manner, and that period especially demands an abundant supply of nutriment.*

109. The former part of this proposition may be supported by the fact that the tastes of mankind are the most simple in the morning. The food usually taken at breakfast is not of a stimulating character, neither is it then common to indulge in much variety of food, yet the desire for and the enjoyment of this simple

meal is certainly as great as that of any food taken during the day. The importance of the latter part of the statement is in practice very variously valued by different sections of the community, for whilst in the northern parts of the country the breakfast table is abundantly supplied with substantial food, a large portion of the inhabitants of large towns, and particularly those living in the southern parts of the island, make a comparatively scanty meal, since it consists only of tea or coffee, with bread and butter, and eggs or bacon are either exceptional foods or are eaten in very small quantity.

110. The object to be had in view in this meal above every other is the amount of nutriment more than the mere quantity of food which is eaten. Hence we may freely doubt if the large amount of tea or coffee which many take at breakfast, say 1 to $1\frac{1}{2}$ pint, is really advantageous, for these infusions contain but very little matter which can supply nutriment; and since they are given at the period of the day when the assimilative functions are naturally active, there is no urgent call for them in their capacity of stimulators of that function. It is, however, clear that they should not be regarded as constituting any important part of the meal, and that an abundance of solid nutriment should be taken whether with or without them. The almost obsolete practice of taking milk as the fluid required at this meal, conjoined with oatmeal and bread, and reinforced if need be with fat or eggs or other solid materials, would be far more consistent with the requirements of the body;

for in the milk we find all the elements of food in large quantity, and proportioned by the master hand to the wants of the human system, and at the same time duly diluted with water. Tea should not be then used, for it exceeds coffee in its power of destroying material, and is therefore opposed to nutrition, except when the natural powers of the system are insufficient to produce healthy assimilation. The remarkable increase of vital action due to the breakfast being associated with a long pre-existent interval in which food has not been taken, implies the necessity for an early breakfast—one taken so soon as the vital actions have assumed their upward tendency.

111. The increase in the vital action was evident in the pulsation so soon as daylight was powerful in summer, but was not marked until the hour when by common assent men usually rise, viz., about 6 or 7 A.M. It was also observed during the morning sleep, but more particularly after awaking, and although it was greatly increased on rising, the increase was still progressive until the breakfast hour, even when the person remained in bed.

112. We cannot doubt that food should be supplied before any large amount of labour is undergone, for with labour there will be increased waste, and before breakfast there is no supply. This remark applies to the large section of the working classes, who by custom work during two hours before they take food, and also to the prisoners in our gaols, and particularly

to tramps, who seek a night-lodging in our work-houses, and must perform a considerable amount of heavy work in the early morning, in order to obtain their breakfast. A system deficient in nutriment, or one in which there is no excess of nutriment, must perform morning labour whilst fasting under great disadvantage, and such persons are not only less likely to do a fair amount of work, but will labour with the certainty of wasting their strength. Hence it is profitable both to the employer and the employed amongst free men, and is bare justice to those who are in confinement that food should be taken before labour is begun. This is in some degree recognised by the French practice, when the bread and coffee are taken very early, and the *déjeûner* is sought at 11 or 12 o'clock, but the former is insufficient to meet the wants of the system, as may be readily inferred from its small nutritive value, and hence the physical power for labour of the Frenchman, instead of being equal to the lifting of about 400 tons to the height of one foot per day, as is the present full capability of the Englishman, is only equal to the raising of from 250 to 300 tons.[1] We need have no difficulty in affirming that breakfast taken before labour is commenced, by those who have to exert much physical power, would enable them to generate more force, and to perform a greater amount of labour than they can under present arrangements effect, and at the same time would tend

[1] Haughton, Dub. Med. Quarterly, Aug. 1860.

greatly to uphold their physical strength. It must be regarded as a cruelty of no small degree to compel the prisoner, or the ill-fed tramp, to perform tread-wheel, shot drill, grinding, or other hard labour before breakfast, when the former, at least, ate his last meal of bread and gruel at 6 o'clock on the preceding night. The same argument is also applicable to those who do not labour hard, but who from poverty or deficient vital power have usually a deficiency of nutriment in the system. This embraces a very large portion of the community, both rich and poor, and perhaps a larger number of the female than of the male sex, and to all such it must be of prime importance that they should eat an early, and as far as may be, a sufficient breakfast. Many of the latter class found relief in past times in the very early administration of rum and milk, a combination pre-eminently fitted to afford nutriment, and to increase the vital powers concerned in the assimilative process, and it is a matter of some gratulation that this, which was formerly an old woman's nostrum, has now received the sanction of science, and is duly supported by the opinion of medical men. The great attention which is now given to the degree of power of assimilation possessed by individuals, and especially in the treatment of the conditions preceding or found early in phthisis, has doubtless brought about this desirable end, and if it should be understood as indicating the necessity for the early administration of food, it will do a yet greater service.

113. It is almost needless to call attention to the plan now under consideration in the treatment of disease, for its importance seems to be self-evident. In almost all cases of disease there is less supply of nutriment than would be proper in a state of health, and this is felt by patients somewhat severely in the period of convalescence. Whether, therefore, it be in the excitement of fever or inflammation, in the craving of convalescence, or in the exhaustion of debility, it is clear that if food be at any time proper it is pre-eminently so in the early morning; and in those numerous cases in which there is defective power of digestion and assimilation and too little ability to take food, there will then be found less feebleness of these powers than at other periods of the day.

114. But to no class of the community is this of so great importance as that of children. In early life the functions are performed with great rapidity, the whole organisation is especially sensitive to adverse influences, and it is of prime importance that the supply of food should exceed the waste of system so as to constitute a sufficient fund for growth. Hence, the interval of the night, in which no food is taken, should not be too prolonged, and as the increase in the vital actions in the early morning is greater in children than in adults, there is the greater necessity for the early and abundant administration of food. To withhold abundance of food from the child is to induce a feeble and ill-nourished system, and lead to an ill-developed man, to the induction of disease, and an unnecessarily early

grave; and hence the supply of food, at the period when the system the most requires it, is the most likely method of averting bodily evils. An abundant, and an early breakfast, is essential to children.

115. It might very properly be asked if the breakfast meal could not be advantageously divided into two parts—one to be taken by the workman before the commencement of physical labour, or soon after rising by children and feeble persons, and the other at a later period, and it must be admitted that there is very good ground for commending this practice. The only condition which needs to be annexed is that the interval between the two parts should be very short, so that within the early morning hours there shall be an abundant supply of nutriment. The evil, already referred to, in the French habit is the long interval which elapses after the very insufficient *avant-déjeûner*, and before the substantial meal is taken. The rapidity with which the increase of vital actions disappears after the breakfast demands an early renewal of the supply of food.

116. The rate of pulsation and respiration and the evolution of carbonic acid were found to be the greatest in one or two hours after breakfast, and at about four to five hours after the meal it was reduced to the lowest point of the working day—a point about ten pulsations per minute higher than that at the lowest period of the night. (Diagrams No. 2 and 5.) Hence it may be inferred that whatever might have been the immediate cause of the increase (and that was the

digestion of food, without doubt), it had at that period passed away, and a renewal of the same cause had become necessary.

117. Hence we defend, and may indeed commend, the early dinner hour of our ancestors, who, although they ate a most substantial breakfast, sat down to a more substantial dinner at 11 or 12 o'clock. It is not unlikely that we are indebted to our neighbours for the habit which prevails of dining at the hour when the old Romans used to sup—a change greatly deprecated by Sir John Floyer more than half a century ago. But in copying their habits in this respect, we have neglected that very necessary condition which they observe, viz., that there should be a *déjeûner à la fourchette* at from 11 to 2 o'clock—a meal which in all respects resembles a dinner—and, in fact, take nothing of a substantially nutritious character between the breakfast at 8 A.M. and the dinner at 6 or 7 P.M. From the facts just referred to, it is clear that a prolonged interval after the breakfast is not desirable, but the contrary, since it must leave the body and mind to sustain all the exertion of the day without supplying the material by which the waste is to be replenished, and will, therefore, lower the tone of health. The truth of this is not generally denied, nay, it is even admitted, for it is the practice of the working classes to take the early dinner, and he who, belonging to another class of the community, defends the contrary course, does it only on the ground of custom or convenience. We may readily admit that many persons

find both bodily and mental exertion less easy after dinner, but the answer is equally ready, viz., that this would not be so, in any appreciable degree, if the amount of nutriment then taken were not greater than the wants of the system required. It is consistent with science, as well as with common sense, to take an early dinner, and nothing could tend more certainly to the improvement of the health and habits of the people than a return to this good practice of our ancestors.

118. In reference to the nature of the mid-day meal, it cannot be wrong to recommend that it should be nutritious, for it is taken at the period of the day when bodily and mental labour is in its full activity; but how far it should be more or less nutritious than the breakfast, is, perhaps, a matter somewhat of indifference. The habits of men usually lead to the consumption of more highly nutritive food at the dinner, and it may be admitted that this is based upon instinctive desire, and, therefore, is a proper habit.

119. *No one in health complains of having taken too much breakfast.*

120. This is explained by the facts given above, viz., the great activity of the process of assimilation at that period of the day, and the absence of previous accumulations of nutritive material in the system.

121. *After the mid-day meal the amount of nutriment supplied should be more limited.*

122. It has been proved that after the middle hours of the day the results of the chemico-vital action within

the system are lessened, and that in the advanced evening they progressively and rapidly diminish, whatever may be the amount of nutriment supplied. This is proved by all the inquiries recorded in Chap. I. on the rate of the functions, the amount of carbonic acid and the quantity of urea evolved, but most strikingly by the lessened excretion of urea at the early part of the afternoon, and by the pulsation at night. Hence it is clearly proved, that the activity of the assimilative function is lessened in the after part of the day, and that quite independently of the nutriment supplied, for if the activity of that function ran *pari passu* with the nutriment offered for conversion, it would increase as the day advanced, or if it proceeded *pari passu* with bodily exertion, it would clearly be at its maximum during the greater part of the day, but it does not closely correspond with either of these causes. (66.) The activity of any function is no doubt in part dependent upon the necessity for it then existing, and upon the presence of that on which its activity may be expended, but it is also dependent upon vital influence. In the case now under consideration, it is probable that as the day advances there is less production of vital influence, and less necessity for the transformation of food, and hence the third condition, or the supply of material to be converted, may readily become in excess, without in any degree altering the activity of the assimilative function.

123. It is therefore to be affirmed that as the day advances there is both lessened activity in the trans-

formation of food, and an increasing tendency to the accumulation of food to be transformed, and hence, on both grounds, the statement is supported that after the mid-day meal the amount of nutriment supplied should be small.

124. Our forefathers were content with three meals a day, and after the early dinner took supper at 6 or 7 o'clock in the evening. They were doubtless too well fed, for at each of the meals the most substantial food was taken, and more than plenty of good English beer was added. It may well be questioned as to how far the nature of the last meal was advantageous to the system, for, as we have shown, there is reason to believe that at the hour referred to the power to make use of the food is greatly lessened, and, in fact, that only a small portion of the food is appropriated to the wants of the system. The same doubt is also clearly applicable to the large and late dinners in which so many indulge in our day, the greater part of which is no doubt wasted, or tends to the injury of the system; but that this very fact is a prime safeguard of the system is a matter of congratulation to those who feast at aldermanic tables, and indulge in a quantity of material which all experience shows to be unnecessary to the wants of the system. Had it been so arranged that with a vicious appetite for food—one too easily acquired—all that we eat must be transformed by the system, the whole economy of the body would be overturned and life be impossible. We are allowed to waste food according to our wishes, but we

have not so much within our power to cause it to be digested and transformed, and it is only after a prolonged struggle that the body is allowed to be injured by it.

125. But to those who rationally seek to nourish themselves, and to supply only so much nutriment as the body requires, the moderate restriction of food in the later part of the day should be commended. The object which should be had in view in the evening is rather the more complete transformation of the food which has been already taken than the supply of a further amount of food, and hence such respiratory and alimentary excitants as tea and coffee are clearly called for. If these should be insufficient, the further supply of solid food, and the consumption of so elaborate a nutriment as milk, must be regulated by the sense of want or satisfaction.

126. It will be observed that this principle is in part admitted, and in other parts rejected, by our actual arrangements. It is admitted by the almost universal practice of taking tea and coffee in the evening; but those who dine late set it aside by receiving in the evening the largest amount of solid food which is taken at any meal during the day. This latter habit has also led to the further one of the use of highly seasoned and artificial dishes, which implies both that the sense of taste is less efficient in the evening, and that some artificial excitement is useful in promoting the transformation of the food then taken,—a habit which, in a striking

manner, supports the statement already made that the vital functions are less active in the evening, and that there ought to be less food supplied as the day advances.

127. *With too much food supplied in the latter part of the day, there is a natural desire for artificial foods or foods of a more highly seasoned kind, and for alcohols, and at that period such substances exert less influence upon the organism than they would exert in the morning.*

128. This is clearly supported by the culinary preparation which is usually made for a late dinner, and the distinction between the early and the late dinner. We have just referred to the fact of highly seasoned and artificial foods being so abundantly supplied in the evening; and to this may be added, the variety of food which is also then taken, all of which are intended to increase the existing desire for food, and excite the activity of the alimentary function. It is not so at an early dinner; but that meal is marked by abundance and simplicity, whilst the late one is characterised by variety and artificial stimulants. This is, in fact, based, as all our instincts are, upon the condition of our system at the two periods, and it would occur to any one to be absurd to invert the order of things, and to give the highly seasoned food in the morning.

129. This being so, is it not clear that the tendency, if duly followed out, must be to give unnatural tastes; and, as a consequence, to lessen the natural tastes of such persons? And, further, is it not

certain that if the system be thus tempted to admit that which it would not otherwise accept, excess of nutrition, and thence depraved nutrition will inevitably follow?

130. It is a well recognised rule of practice not to take alcoholic stimulants in the morning; but, let us ask, why should we not then take them? One answer would undoubtedly be, that there is then but little desire for them, and that is a truth, based upon the fact so often insisted upon, that the vital actions then require no artificial support: but it is further true, that alcohols at that period of the day produce far more intoxicating or poisonous effects than they exert in the evening. A man given to morning dram-drinking or to morning intoxication is regarded as one on the high road to the grave.

131. The scientific ground for the encouragement of wine and spirit drinking in the latter part of the day is the reduction of the vital powers which is then experienced, and the excess of nutritive material which is then so commonly present in the system. This view may be earnestly commended to those who desire to lessen the amount of alcohols used by the community. The surest course to moderation in, or to the abolition of, the use of such stimulants amongst a rational people, will be to establish a more suitable distribution of the nutriment through the day, so that, whilst there shall be no want, there shall be no evening excess of it in the system, and also to clearly understand that the failure

of the vital powers in the evening is a natural condition of the animal system. The latter state must, therefore, be admitted as a necessary part of every man's life, and be remedied by early retiring to rest rather than by the use of stimulants to bring about an unnatural degree of action—one opposed to the occurrence of sleep and early rest. The question of the use of alcohols is one indissolubly associated with all the habits of a man, and just in proportion as his habits are based upon the instincts of his nature, so may he banish all artificial stimulants from his table. Simplicity and frugality are as surely based upon our instincts and lead to health, as excess, variety, and artificial meats and drinks are opposed to the dictates of our nature, and tend to disease. Evening excess of food leads to the use of stimulants; both lead to late hours, and all induce disease.

132. *Early retiring to rest is clearly indicated.*

133. It has been shown that in the evening the rate of pulsation and respiration, and all the products of chemico-vital action, rapidly diminish, notwithstanding the presence of those influences which commonly sustain them, and that the fall becomes very rapid at about 10 to 11 o'clock at night. Hence it is evident that Nature is thus not only conserving the system by lessening the waste then proceeding, but is seeking those most natural and necessary restoratives—the horizontal position and sleep—and it is our duty to listen to her dictates. Those who perform physical labour at that period must certainly do so under cir-

cumstances most disadvantageous to the production of power, and at an unusual expense to the system.

134. *Food should be taken in the night only under exceptional circumstances.*

135. This doctrine has already been indirectly insisted upon, for if it be improper to administer much food in the after part of the day, on account of the natural decline of the vital powers, it must *à fortiori* be more improper to give it in the night, when the vital powers are at their lowest point. But as it is the ordinary habit of mankind to devote the night to sleep, we need less to insist upon the avoidance of food at that period than to show the grounds for its exclusion.

136. The ability of mankind to habitually fast twelve hours through the night, when it would be impossible to do so through the day, is due to the lessened amount of vital action and the smaller amount of waste proceeding at the former than at the latter period; and that this is a natural state of things may be inferred, not only from our ability to do it, but from the fact that it conduces to the soundness of the night's rest. Hence we assume that food should neither be taken late at night nor during the night, lest, by doing so, we disturb the enjoyment of a natural instinct by the digestion and assimilation of food preventing the subsidence of the vital actions to that point at which sound sleep may be attained.

137. The exceptional conditions are of two kinds. First, in cases of Consumption, it has been shown,

(Diagrams 2 and 3), that the subsidence of the rate of pulsation during the night is much greater than in health, and that the greater difference between the day and night rate in Consumption than in health, is less due to the increased elevation of the pulse during the day than to the great subsidence of it through the night. It is therefore a question of interest if the continuance of this very large subsidence of vital action through many hours in a system greatly enfeebled be not very likely to increase the debility and need to be lessened. This view is supported by the fact that perspirations, which may be shown to be caused by and to cause feeble heart-action, occur most profusely at that period. In this case and also in other states of exhaustion in which the vital powers are reduced, and the amount of nutriment taken is lessened, it is of great moment to prevent so long an interval occurring between the night and the morning meal, and therefore we commonly direct that food should be taken once or twice in the night, or in the very early morning, and by this means the profuse perspiration and the sense of great exhaustion which such persons feel in the early morning are in great part avoided. The common habit of feeding infants in the night is doubtless based upon the same grounds, but in addition to these the rapidity of the process of assimilation in infants calls imperatively for the frequent administration of food, whether by night or day.

138. In all cases of great exhaustion and those of

unusual activity of the vital processes, as in many nervous persons, this plan of procedure may confidently be urged, and in phthisis there is this further reason for its adoption, viz. that as the perspirations are less profuse in day sleep, when the vital powers are high, it is reasonable to indulge sleep at that period, and restrict it in the night, when their effect is far more exhausting.

139. The second exceptional condition is that in which there is night watching, with or without muscular exertion.

140. The inquiry made upon ourself when awake during three days and nights without intermission, proved that even with constant watchfulness and some amount of exertion at each hour of the day and night, there was still a large diminution in the rate of pulsation and respiration as compared with that of the day (table 2, æt. 36), but it was to a less degree than would have occurred with sleep. It was also proved that the influence of two meals taken in the night, although perceptible, was small, and did not at all equal that which would have occurred in the day. From this we infer, that as there is more waste proceeding in the night with wakefulness and labour than with rest and sleep, there ought to be a due supply of food given to meet it, and that such persons should take food at the same intervals as they would observe during the day; but it is also clear that although this may be effected, the nutrition of the system will be far less effective than if the same nutriment had been taken through

the day. Hence one most serious evil of night watching. We also noticed that the administration of good meals of tea and bacon twice in the night not only prevented sleep, but, so far as we could perceive, in some measure removed the temporary necessity for it, for during the seventy-two hours we never had any serious desire to sleep; and as all experience shows that sleep is necessary and cannot be replaced by any agency, we may infer that the condition referred to would necessarily add to the ultimate exhaustion of the system.

VARIATIONS IN THE QUANTITY OF BLOOD.

141. The fact that the blood varies in quantity is not generally appreciated in practice, but most persons regard that fluid as a tolerably fixed quantity. The least reflection will, however, satisfy an inquirer that the quantity must vary every hour, and in his own person he has after every meal evidence sufficient to satisfy him, if he regard his own sensations, the fullness of the pulse, and the increased fullness of the hands and face. The variation is not a fact which can be demonstrated by exact admeasurement, but it so certainly follows as a necessary result of certain conditions that the evidence adducible is almost equal to a demonstration. The importance of this variation must be great, if the effect oftentimes produced by the abstraction of one pint of blood may be accepted in proof.

142. *The largest quantity of blood is found within two hours after each meal.*

143. When as at breakfast or dinner one pint of fluid is taken into the stomach with one-half to a pound and a half of solid food, which itself contains water, and is subsequently rendered fluid, it must enter the blood before it can be applied to the purposes of the body, or be emitted by the skin and kidneys. The whole of this material would not enter the blood-vessels at the same moment, but as we know that the absorption of fluid from the stomach is very rapid, we may be assured that after such a meal the amount of blood will be increased by at least one pint. This increase will be to the extent of more than one-thirtieth of the total volume of the blood, and be evident both by giving general fullness to the body, and special fullness and frequency to the pulse. It will commence within a very few minutes after the beginning of the meal, and increase during a period of $1\frac{1}{2}$ to $2\frac{1}{2}$ hours, and after remaining at the maximum for a short time, it will decline to a low point before the following meal. In these respects it doubtless follows the course of the frequency of the pulsations as delineated in Diagram No. 2. Hence throughout the day there are several alternations of increase and decrease in the quantity of the blood, corresponding closely with the variations in the rate of the vital changes which have been already noticed.

144. *The period of the day when there is the greatest amount of blood is usually in the afternoon, but it*

depends much upon the period of meals, and the amount and kind of fluid and food taken.

145. As solid food must be reduced to a fluid state during the process of digestion, a large portion of the fluid taken is appropriated to this purpose, and is thus retained by the body. As therefore food is repeatedly taken during the day and accumulates in the system so must it become temporarily fixed, and the volume of the blood be thereby increased for a longer period. This is the condition commonly found in the later hours of the day, when food has been taken abundantly, frequently, and until a late hour, and hence it may often occur that the blood will be in the greatest volume, and be the most loaded with nutritive material in the evening. But in the instance of those who frequent spas and drink a pint and a half of fluid before breakfast, it is highly probable that the volume of blood approaches to or attains the maximum in the morning, but in such cases it simply enters the blood to be again quickly thrown off from it after it has removed certain soluble matters from that fluid. According to the specific gravity of the fluid taken, will this excretion be effected by the bowels or by the kidneys, and when the fluid taken was pure water, we have found half-a-pint taken thrice at intervals of half-an-hour cause an emission of nearly 70 ounces of fluid by the kidneys within three hours. (76.) In such a case whilst the volume of the blood might have been raised to a maximum, it was speedily reduced to a mini-

mum, and thus the two extremes were brought close together.

146. We have already shown that in the ordinary course of taking food, the amount of water excreted by the kidneys lessens as the afternoon and night advance, but it does not follow that there is then the least total evolution during the night, because at that period the hourly rate is commonly the least, for the long interval of the night in which no fluid was taken might permit a larger emission of urine between the supper and the breakfast than occurs between two earlier meals of the day. The quantity emitted at night depends essentially upon the amount of fluid which has remained fixed through the day, modified by the amount and kind of food and fluid taken at the last meal.

147. *The dangers resulting from excess of blood occur chiefly in the evening, and increase after each meal.*

148. The dangers due to excess of blood result either from the rupture of a bloodvessel, by which blood is thrown out in quantity to cause danger by exhaustion, or by being effused into structures which are important to life, or from the arrest of the circulation at the heart, or in other vital organs. The former is more purely due to mere increase in the volume of the blood, whilst with the latter is commonly conjoined some obstruction to the current of the blood, as in the capillaries of the skin, or liver, or some defect in the vital power of the heart to duly propel the column of blood. The latter condition is

therefore variable in its period of occurrence, but the former will manifestly correspond with the period of greatest distension of the bloodvessels, (exertion being of course excluded in these observations), and therefore in the evening, if during that period there should have been an abundance of food taken, and a large quantity of fluid have been retained with it. Hence apoplexy commonly follows a meal, or occurs late in the evening, as do also active congestions and inflammations not directly resulting from exposure, and it is manifest that all those persons who are predisposed to these dangers should both be watchful at the periods indicated, and seek to restrict the increase of the blood within narrow limits.

149. *The dangers from defect of blood occur mostly in the middle and advanced hours of the night, also in prolonged intervals between meals, and after unusual emissions of fluid.*

150. It appears that a certain degree of fulness of the bloodvessels is requisite to the carrying on of the vital processes, for it is necessary to consciousness, as is proved by the effect of abstraction of blood. Hence there is a certain relation between the amount of blood and the amount of vital power; and the latter is at its minimum in the night, as shown, not only by the rate and activity of the vital functions already described, but by the well-known fact that death occurs much more frequently from 1 to 5 A.M. than at other hours of the day and night. This necessary fulness of the bloodvessels can be maintained only with great

difficulty in certain states of disease, as in those cases of phthisis and general debility of the system which perspire profusely at night. The amount of fluid thus lost has not been estimated, but from the saturated state of the bed-clothes and the matted condition of the hair, it must be very great—probably as much as 2 lbs. in weight during the night; and since in such cases it is not usual for them to take fluid during that period, it is manifest that the volume of the blood must be diminished hour by hour as the night advances, and a condition approaching to *deliquium* inevitably follow. This will explain the sense of profound exhaustion which such persons feel, both on awaking in the morning and after sleeping during the day, for in both conditions alike there is the same want of vascular fulness to maintain the sense of *bien aise* and the activity of the vital processes, although the degree of it may vary and be the greatest when the vital powers are at the lowest point, viz., during the night.

151. Another pertinent illustration is found in cases of severe diarrhœa, and particularly in cholera, in which the loss of fluid amounts to many pounds' weight in the course of a few hours. Such cases are always marked by profound exhaustion, greatly lessened vital action, and feeble or imperceptible pulsation, all of which are immediately due to the deficiency in the volume of blood, for when transfusion of blood has been performed, and thereby the volume of blood increased, they instantly seem to receive new life.

152. The general characters of such a case precisely resemble those of extreme flooding after parturition.

153. In less extreme cases than those just mentioned, and in all persons in whom the interval between the meals is too prolonged, the danger will be proportioned to the remaining power of the system; and those who are feeble, whether from disease or from defective constitution, will be the most ready to succumb.

154. In all such conditions it is of great consequence to supply food with fluid frequently and abundantly at the periods of danger, as has already been insisted upon. It should be of a nature tending to sustain the action of the heart, and to lessen the action of the skin, and such we have in another place shown to be milk, coffee, and alcohols.

155. *The dangers, whether from excess or defect of blood, are materially modified by change of posture of the body.*

156. In cases of excess of blood, in which the danger is chiefly referable to the brain, the change from the standing to the lying posture is a most frequent cause of an attack, because the volume of the blood is then more freely distributed to the brain than it could have been, when in the standing posture the column of the blood gravitated from the head. If there be disease of the heart by which the force of the current is increased, it is manifest that this force of the heart's impulse will be yet greater when the horizontal position is taken, and will act directly upon the volume of blood distributed to the brain.

157. In cases where the danger is referable to the lungs, as, for example, active or passive congestion of those organs, change of posture from standing to sitting may be injurious, by lessening the rapidity of the current of blood. The difference in the rate of pulsation between these extreme postures is very variable, but sometimes it is very great, as a range of from ten to upwards of thirty pulsations per minute, and in cases of congestion nothing is more important than to maintain a sufficient rapidity of the current of the blood.

158. In all such cases we find the reason for the increased danger which manifests itself on lying down at night, and such are cases of apoplexy, pulmonary hæmorrhage, disease of the heart and great vessels, and visceral congestion. The opposite class of cases, or those in which the danger is connected with defect of blood, have the danger always most imminent on the lying posture being exchanged for that of sitting or standing. The effect of this change of posture is to lessen the relative force of the heart's action, and to cause a withdrawal of that volume of blood from the brain which is essential to consciousness, and probably to life. Such are cases of weak heart, in which the force of the heart is at all times deficient—cases of debility, and all cases of continued disease in which there is imminent peril to life, and in which simply raising the body in bed suffices to bring on the catastrophe. Death, in such cases, commonly occurs from imprudent change of posture during the night, or at

the usual period of rising in the morning. It is also not unusual to find hæmoptosis occur from change of posture in the morning, and in such instances the hemorrhage is due probably to the sudden revulsion of the current of blood from the head to the central and lower parts of the body.

159. As the dangers thus pointed out are associated not so much with any posture as with the change of posture, they may be in great measure obviated by making that change slowly, and, as far as may be, by degrees, and when the new posture has been maintained for a short time the danger subsides.

VARIATIONS IN THE HEAT OF THE BODY.

160. In considering the question of the heat of the body, it is requisite to regard it in three aspects, viz., the production of heat, the dispersion of heat, and the actually existing temperature of the body.

161. *It is believed to be well established that the normal temperature of the body is nearly uniform, and varies but two or three degrees under whatever normal conditions the body may be placed.*

162. This fact has long been established, but the recent observations of Dr. Brown-Sequard upon himself in more southern latitudes, and those of Mr. Ringer on Fevers, may be selected from similar researches, to prove that the standard of temperature is not absolutely uniform, but may vary from a point below 98° to a point above 102°. It is, however, to be borne in mind that all observations of this kind have only a

limited application, for as they were made with the thermometer placed in the armpit or within the outlets of the body, it is not by any means certain that the temperature indicated at these points was that of the central parts of the trunk, and it is quite certain that it in no degree represented the temperature at the surface. Whilst the internal parts of the body have a temperature of 98° to 101°, the heat of the extremities may be found in winter so low as 50°, 60°, or 70°; and hence it is in the highest degree probable that the actual average temperature of the various parts of the body varies very considerably under different conditions.

163. *This variation results from changes in the development and distribution of heat.*

164. The production of heat varies as the amount of vital action in the body and the temperature of the surrounding air. Hence, in the first condition it must be at its minimum during the night, before breakfast, and at the end of the intervals between meals; whilst the maximum is found during the day, and within two hours after each meal, but particularly after the early meals of the day. It is still a desideratum to determine this in man experimentally, but the above assertions correspond both with all physiological knowledge and with our own sensations. The latter source of variation, or the temperature of the surrounding air, also causes more heat to be supplied to the body in the day than in the night, and gives a progressive increase through the morning and

the middle hours of the day, after which there is a progressive decline.

165. The causes of loss of heat are (besides the temperature of the surrounding air) chiefly the action of the skin in which the fluid passing into a vaporous state absorbs and renders latent 1000 times more heat than it held as a fluid, which it must extract from the body and surrounding air; also the evolution of heated air from the lungs and the fluid and solid excreta. As the resulting temperature is tolerably uniform whilst the production of heat is very variable, it is evident that the due regulation depends upon the dispersion of heat. Hence the skin is the prime heat regulator of the body and must vary in activity as the production of heat varies. In the truly normal condition of things there is a most exact adaptation of these two processes, so that with great variation in the supply of heat there is no very marked sensation of heat; but as alcohols, fat, and animal foods have been shown by us to lessen the action of the skin, they are apt to disturb this harmonious action, and when taken beyond the requirements of the system they certainly increase the sensation of heat and particularly in the extremities and exposed parts of the body. Hence it follows that ordinarily there will be a greater tendency to the increase of the heat of the body after the dinner, and common experience shows that then the hands are not unfrequently hot, whilst after the tea meal the increased action of the skin induced by the tea more than counteracts the effect of the increased

production of heat, and with perspiration the body becomes cooler.

166. *The dangers from excess of heat are the greatest at and after the middle of the day.*

167. The precise mode in which excess of heat acts within the body has not been demonstrated, but the general results may be well traced in common fever, in which there is a longing for cooling fluids, a detestation of heat-producing food and such other foods as lessen the action of the skin, and also a general shrinking of the body and exhaustion of nervous power. The evils of excess of heat no doubt occur in the effects of sun-stroke, for that disease is found under conditions in which the supply of heat is very great, and as the skin is observed to be excessively hot and dry during the attack there is a limited dispersion of heat. In both of these conditions it has been shown that in the afternoon and the evening the danger is largely increased, whilst in the advanced hours of the night and in the early morning there is the nearest approach to the normal state. Hence, where such diseases exist or where there is imminent threatening of them, it is imperative that food and exposure to heat be much restricted during the day and allowed at night and in the early morning.

168. *The dangers from defect of heat occur in the night and in the early morning.*

169. These dangers occur chiefly in cold climates and in the cold seasons of temperate climes, and fall most heavily upon the young and the feeble. It is

commonly observed that the coldest part of the twenty-four hours is soon before sun-rise, and this results not only from the circumstances which affect the temperature of the external air and which are well known, but from the diminished amount of heat generated within the body as the night advances. This truth has been most commonly observed by travellers exposed to nocturnal influences, but it is felt by all who undertake night watching without food in even an uniform external temperature, and by those who sleep imperfectly in the early morning, and is known to those who watch by the bedside of children in health and of all persons in sickness. The low temperature of the breath of persons much enfeebled, as* in advanced phthisis, in the early morning is perceptible to the hand of the inquirer. The dangers of defective heat are certainly oppression of the nervous system, defective vital transformation, and generally lessened functional activity. Hence at the periods indicated, those who are exposed to these evils should endeavour to avert them by food or exertion or artificial heat, and those who have charge of infants or of sick people should be duly cautioned as to the dangers of the morning hours.

170. It has ever been questioned as to how far alcoholic liquors are truly beneficial to those exposed to the morning cold, and whilst it may be conceded that if suitable food be taken they are unnecessary, it cannot be denied that in the absence of food they exert a powerfully beneficial action. This is doubtless due rather to their power of preventing the dispersion of

heat by lessening the action of the skin, than to any power which they possess of increasing the production of heat, for whilst the former is certainly true the latter is at least doubtful, and except in the case of ales and rum may be denied without much risk of error. Hence in this important direction, alcohols may be safely added to milk, fat, and animal food already stated to have the power of lessening the action of the skin, and the old compound of rum and milk, of more than half a century ago, may not improperly be recommended in the exceptional condition just described.

171. *The arrangements in reference to the clothing of the body tend to lessen the variations of the heat of the body.*

172. There can be no doubt that, other things being equal, the skin is the most active when the vital processes are lessening, as during the night, in the morning, and at the end of the intervals between meals, for after meals, and especially after dinner, the hands and other parts of the skin are both hot and dry, whilst in the night and the early morning the skin is soft and natural. At the same periods there is less fulness of the superficial parts, as has already been shown when treating of the distribution of the blood, and there is also the greatest sensibility to cold. Hence it is the custom to use more clothing in the night than in the day, as is proved by the number of layers of woollen or other fabrics which cover the body when in bed as opposed to those of the clothes worn during

the day. In the early morning in the cold season it is known that there is especial liability to take cold in those exposed to the external temperature, and particularly in the heavy dews found in hot climates, and then an amount of clothing is required which would be excessive in the earlier part of the night. During the day we lessen the amount of clothing and vary it according to the dictates of that most invaluable monitor the sensibility of the skin, and thus instinctively seek to aid in maintaining an uniform temperature of the body. The skin, as has already been shown, regulates heat rather by providing against excess of it than by materially aiding in retaining it when it is in defect, and therefore it has been most wisely arranged that the former action shall take place as a self-regulator without calling for our aid, but the latter asks for our instinctive and rational help, by giving us a sensation which cannot pass unheeded. Hence, whilst clothing is comparatively powerless in the direction in which the skin is almost omnipotent, it is or may be efficacious in the direction in which the powers of the skin fail us. This is true of all climes, but in hot countries the temperature of the external air, whether by night or day, so nearly approaches to that of the body, that with the necessary vital action from food, the sole duty in regulating the heat is to prevent an excess of it, and therefore protection from the sun and not from the cold, is in constant requisition. Clothing in such cases is almost a dangerous luxury.

173. *Excessive clothing at night is highly injurious.*

174. In order to effective sleep there should be such a balance in the production and dispersion of heat that no sensation of temperature may be perceptible, for if there be too much heat, whether from production within the body or from external supply, the skin must put on an undue amount of action, and perspiration in a more or less exhausting degree will result; or the heat of the body being in excess, the action of the heart becomes increased, the blood is urged with greater vigour to the brain, and is largely distributed to the superficies, and in general the whole vital actions of the body are unduly excited. Hence excessive clothing will either tend directly to exhaustion by the action of the skin, or indirectly by inducing a higher amount of action in the night than is consistent with sound sleep and subsequent re-invigoration of the body. In those, therefore, who on the one hand are feeble or on the other are liable to hæmorrhage or to apoplexy, this would greatly aggravate the evil.

CAPABILITY FOR BODILY AND MENTAL LABOUR.

175. It is unnecessary to stay to prove that there is much variation in the capability for and desire to labour at various periods of the day, for it accords with the personal experience of all men, and our sole duty will be to explain the variations, and assign the grounds for them. As muscular exertion, and probably mental labour also, leads to the waste of the body, it should be made when there is both the largest

amount of force existing in the body, and the greatest amount of vital action fitted to repair the waste thus induced.

176. *The period most fitted for bodily labour is from the breakfast until the evening.*

177. It has been abundantly proved in the preceding pages that the vital action proceeding in the body during the day is much greater than that in the night, and the limits of the former period have been shown to be the breakfast hour in the morning, and from 6 to 8 o'clock in the evening. Between these two periods, there is every preparation made by the body to sustain muscular exertion, and to repair whatever waste it may occasion.

178. There has been an attempt of late years to curtail the amount of labour required from those who act under the control of others, and in many instances it has been successful, and has led to the best results. Regarding this question purely in its bearing upon the physical system of man, that is, apart from moral and educational considerations, we cannot forbear the expression of opinion that the limitation has been effected at the wrong end of the day. At present the limitation is restricted to the evening, and it is sought to terminate labour at about 5 or 5½ P.M., whilst all reference to the morning hours has been omitted. But it has been shown that in the healthy, vigorous, and fairly fed human system, the vigour of the body is maintained at a tolerably high standard until a much later hour, say 8 o'clock; and although

the power of assimilation is then reduced, it is probably less owing to diminished vitality than to the lessened necessity for nutriment which then exists. After about 8 P.M. the powers of the system lessen, and the subsidence is thenceforward most rapid; but at present we omit reference to the night, and limit our attention to the hours during which the vital actions have been shown to be at a tolerably high standard. If, therefore, the economic basis of the amount of labour which may be borne without injury be accepted as the ground upon which to found regulations for labour, it cannot be denied that the present restriction to so early an hour is uncalled for by the powers of the human system, and it may be affirmed that those powers are equal to labour up to 7 P.M., and perhaps until 8 P.M.

179. The period for which new arrangements are imperatively called for in the interest of the working classes is the early morning. We have proved that at about 7 A.M. the vital actions of the system are very low—lower than is found at any other period of the day-light day, and until the breakfast has been taken, they remain very greatly below the average amount of the day. But according to present arrangements, the day's work is entered upon at 6 A.M., and as a consequence the labourer must rise probably at 5 A.M., and may have to walk some miles before he enters upon what is regarded as his day's work, and then until 8 o'clock labour must be carried on with a system inadequate to the muscular exertion, and with

an amount of vital action totally unfitted to repair the waste which is thus induced. It is a mistake to suppose that the human system possesses its greatest amount of force in the early morning, because then we feel refreshed and active; for, on the contrary, it is then ill-fitted for labour until duly invigorated by food, and tolerates exertion only at a great sacrifice to itself. This has indeed been recognised as a truth in reference to children, for the Factory Act forbids their employment at an early hour; and it is much to be regretted that it is not understood in reference to females especially, and to the labouring classes as a whole. Our convictions are strong that labour should not be exacted in these early morning hours, or it should be accompanied by a yet earlier, and a quickly repeated meal of good food. The present arrangements cannot be otherwise than injurious to the working classes themselves, and they are by no means to the advantage of the employers, for it is notorious how apt is the result to be inadequate to the hours occupied and the money paid for it. It is a perpetual struggle between the two classes—the one trying to evade a condition which is unnatural, and the other seeking to obtain the labour which is universally conceded in the morning and actually denied in the evening. In our opinion, no laborious occupation should be followed in this climate before 7 A.M., and it ought in all instances to be preceded by the breakfast. If this plan were adopted it would do much to save the health of our weakened population,

to prevent the distrust between employer and employed, and to obtain a fairer amount of labour from a given day's work. The period of the day in which the human system is the *most* vigorous and fitted for labour in our climate, is from about 8 or 9 A.M. until 4 or 5 P.M., but it is sufficiently vigorous for a longer period.

180. The necessity for a period of rest after each meal, both in reference to the digestion of food and the fitness for physical labour, is also a disputed question. It has been proved that violent exertion immediately after a meal is not favourable to digestion; and it is a matter of common experience that we feel indisposed to labour soon after taking food; but the qualification of these remarks must not be unheeded, viz., the degree of labour and the fulness of the meal. No evidence has been adduced to show that moderate labour impedes digestion; but, on the contrary, the experience of men shows that those who labour both eat more food and demand food again more rapidly than those who are at rest, and hence there is a *primâ facie* reason for believing that their labour does not impede digestion. Again, the indisposition to labour after a meal varies with the amount of food taken in relation to the wants of the system, the digestibility of the food, and the powers of digestion, and it is reduced to an insignificant amount when food is not in excess of those conditions. When, however, the food is chiefly composed of starch, and not accompanied with any stimulant,

whether fluid or solid, the oppression resulting from a large meal will materially impede the power to labour. So, in like manner, after taking any noticeable quantity of alcohol, there can be no doubt but the physical power is temporarily lessened.

181. Hence if too much food be taken, and especially if it be of a starchy kind, and when much alcoholic stimulants are added, we cannot doubt that a period of rest is really advantageous, if not necessary, but on the other hand if the food be moderate in quantity and simple in quality, rest is not essential to its due digestion, and so far it may be dispensed with. We believe that the following rule should be obeyed, viz., that when there is a sense of oppression after meals not due to defective powers of digestion nor to improper food, the quantity of food taken is in excess, and should be lessened. There is, however, another question involved in that under discussion, viz., the necessity for rest to relieve the previous action of the muscles, but into this we do not enter further than this—that as rest is a necessary alternative to labour, and as small meals are conducive to muscular exertion, it is worthy of consideration if those who are engaged in manual labour for many hours would not perform it with more ease if there were more frequent, but shorter intervals for rest and for meals, instead of the three meals a day at long intervals, with the single long interval of rest between 8 A.M. and 6 P.M. It is very probable that more work would be done, and at a less cost to the workman.

182. *The night is unfitted for physical labour.*

183. The common arrangements of society and the instinctive desires of man seem to render any remarks under this head unnecessary, but there are many who cannot conform to the well-established rule, and many others who are ignorant as to the injury which accrues from this exceptional conduct.

184. It is known that the arrangements of the police require that a certain portion of them should labour through the night; but it is not so commonly known, as it should be, that a policeman is placed upon night duty for many weeks and months without intermission. It is also known that some of the compositors and printers in the newspaper trade work habitually at night, whilst many others do so at intervals. So in like manner bakers work through the night, whilst tailors, milliners, and dressmakers are required to do so on pressing occasions. The evil effects of night marching upon soldiers have been well established; but in hot climates, as in India, the early morning marches are much less injurious than marching under a burning sun. In the instances in which it has been practised in Europe it has been found that a large proportion of the force fell out of the ranks within a few days.

185. In these various occupations there are special conditions attaching to each one which may increase the evil, as for example the heat and confined air of the workshop, or the cold, damp, and miasmata of the open country, but there are four evils which are

common to all, viz., inadequate vital action, loss of sunlight, imperfect day sleep, and ill-arranged meals.

186. The low amount of vital action during the night has been already proved, and has been shown to occur from about 10 P.M. until 6 or 7 A.M., but having its lowest point from 1 to 3 A.M. This depression occurs whatever may be the conditions in which an individual may be placed, and does not depend upon rest and the horizontal posture as was assumed by Dr. Knox and others, for in our own case when occupied every hour during three days and nights in succession, and never asleep during that period, there was always a marked diminution of vital action in the night. (Table 2.) Hence at that period there is the least power to support physical exertion, and to repair the waste induced. It is therefore almost impossible that the same amount of physical force can be exerted in the night as in the day, and it is certain that no approach to it can occur without injury to the system. Hence employers and employed are alike injured by night labour, and so strongly is this felt by the working classes, that in many trades night labour is charged at a double rate.

187. Sunlight is undoubtedly powerful in sustaining vital action, and in some of our experiments we proved that it increases the morning pulsation ten or twelve beats per minute. Hence the absence of it at the period when the greatest vital action is required must be one of the elements of injury.

188. In reference to day sleep, it appears impossible

that it should be as sound and invigorating as that obtained in the night, although on inquiring from persons performing night-work, we have been informed that after a certain period of training they do sleep soundly. The reason for the view which we have taken is based upon the fact that sleep is naturally sought by the whole animal kingdom in the night when the vital actions are at a minimum, and is the most profound when they are at the lowest point; also that anything which tends to increase the vital actions, as late suppers, certainly prevents sound sleep, and hence we infer that low vital action and sound sleep must be associated. But in day sleep, although the pulsation has been shown by us to be 10 per minute lower than is observed during wakefulness, it is still at least 10 higher than occurs at night. In fact it is as impossible to reduce the vital actions of the day to the low standard of the night, as it is to raise those of the night to the standard of the day. Hence day sleep and night labour are both inverting the natural order of circumstances.

189. On inquiry, we find that persons at night-work do not take their food with the regularity with which those take it who work by day, so that for example, the baker before going to work at midnight will take an ordinary meal, and work until 6 or 7 A.M. without more food, or with only a meal of tea at 4 or 5 o'clock. On returning home, say at 8 A.M., a breakfast is taken, and he retires to rest for a pre-arranged number of hours. Hence it is clear that during the

hours of labour, the amount of nutriment taken is altogether inadequate to meet the existing requirements of the system, whilst during the day the powers of digestion are reduced by sleep, and the taking of food at the period of the day when the system both needs it, and can well digest it, is prevented. Such persons must therefore not only labour when they cannot repair the waste, but must be ill fed, and the food be ill assimilated.

190. With this combination of ills can it be a matter of surprise that the night-worker is very prone to disease, and especially to consumption, and can a community tolerate any arrangements which render such a sacrifice necessary? Already the late and early hours of the needle-woman have attracted attention; baking by machinery is fast supplanting the old night-work kneading; and if the policeman and the printer cannot altogether quit their occupations at night, we trust that the time is near when night-work will be alternated at certain intervals with day-work.

191. *The periods most suited for mental labour are the morning and the evening.*

192. The experience of the student is that he cannot study after meals, for then there is a sensation about the stomach and chest which attracts his attention, and a sense of oppression or cloudiness of the mind. He cannot rigidly fix his attention upon any subject, much less can he so grasp his subject as to be able to chisel out new ideas. The hours of primary digestion are, indeed, his worst hours unless he adopt

the rational precaution of taking less food at a meal than his appetite would indicate, or of devoting the hour after a meal to bodily recreation. It is undoubted that for mental labour these hours are always inferior in value to those which precede a meal. Hence we infer that the period of highest vital action is not that the most fitted for mental labour, and in this we see a great diversity in the condition suited to mental and physical exertion, for whilst a quiet non-stimulating diet and little bodily exertion seem fitted to aid the student, a more generous dietary and greater muscular exertion tend to induce physical power. So far the conditions are antagonistic, but the latter alone comports with vigorous health.

193. In the early morning the system is light, free, and refreshed, unoppressed by the digestion or accumulation of food, and then also the mind is calm and but little disturbed by the anxieties of life. This, then, pre-eminently is the period for mental activity, if not for mental vigour, and the proverb that "one hour in the morning is worth two hours at night" is true more of mental than of physical labour.

194. Next to this, in point of value, is the prolonged interval after the breakfast and before a somewhat late dinner, when the effects of the breakfast have subsided, or the evening hours from 7 or 8 P.M. for those who take an early dinner. The experience of students and authors seems conclusive upon this point, and the custom of "wasting the midnight oil"

is not originally the result of ill-arranged habits, but of the enjoyment of the quietude and peacefulness of the night. When the vital actions begin to decline, and until they have subsided to their lowest point, the mind again breaks through the fetters of the body, and unoppressed by the effect of food may act with steadiness. It is quite open to question as to the power and even rapidity of thought at this period, for it is calmness and ease which are then the leading characteristics of the mind, and it is well known that many of our most brilliant poets have not only laboured through the night but have required the aid of artificial excitants in order to obtain the required freedom and vivacity of thought. It is, perhaps, scarcely sufficiently understood that the various productions of the mind require not only different minds but minds acting under different conditions; and it is quite within belief that vigorous and masculine thought is more properly associated with the vigour of the day, whilst routine study or the peaceful flow of ideas is most at home at night. The action of tea or coffee is very beneficial for the purpose of increasing mental action, if it be not taken with a view to prevent the restorative effect of sleep which nature is then seeking, but for the purpose of promoting the assimilation of food, and of removing the oppression which attracts the attention of the mind.

PERIODS OF THE ATTACKS OF DISEASE AND THE ADMINISTRATION OF REMEDIES.

195. No part of our subject can have greater interest and importance than that which points out the natural variations of the day and the periods when the attacks of disease are the most imminent, and when remedies of whatever nature may be the most efficaciously administered, for it embraces the two divisions of the medical art, viz., the prevention and the cure of disease. It is also one to which too little attention has been given, but one at the same time which science is now enabled to enlighten.

196. In the administration of remedies scarcely any regard is paid to these natural variations, and the only general rule laid down is to avoid the meal hours. It is the practice to give medicine three or four times a-day, without our having determined the duration of the effect of each dose, and to give certain medicines as purgatives at night or in the morning indiscriminately; but since the conditions under which any particular state of disease occurs vary in their influence at different periods of the day, it is only rational that the value of these conditions should be duly estimated. Moreover there is a daily cycle in the progress of predisposing influences, and as these attain their maxima and minima once or twice in the twenty-four hours, there is a progressive increase in their power up to a certain period, and thence a progressive decrease. The efficiency of the remedy will as much

depend upon the right period being chosen for its administration as upon its own properties.

197. In discussing this subject we desire to keep two general principles prominently in view, viz.: that sthenic manifestations occur chiefly in the day, and asthenic ones in the evening, night, and early morning, corresponding to the amount of vital action naturally proceeding at those periods, and that the remedies severally applicable to those conditions should be chiefly or exclusively applied at these periods.

198. *In states of debility there is the greatest exhaustion in the evening and in the early morning.*

199. Persons in states of debility often need nutriment at night and an early breakfast, and at both periods are unfit for exertion until this food has been obtained. In such instances it is perhaps necessary that supper should be allowed, for otherwise the subsidence of the vital actions during the night would be too great to maintain the requisite fulness of the blood-vessels and a due amount of vital heat, and, consequently, further exhaustion would follow. During the day this class of patients enjoy tolerable comfort, unless the interval between meals be too prolonged, for then the effect of food and sunlight suitably elevates the vital powers.

200. Hence in the administration of stimulants and general tonics, the morning and the evening should be especially selected, and the doses be repeated at much shorter intervals than is called for during the day;

whilst food may be regarded as the proper medicine for the latter period.

201. *In conditions of mal-assimilation of food it is important to apply all suitable remedies during the middle periods of the day.*

202. This inference follows from a consideration of the natural requirements of the body, and the period when the vital powers should be well sustained, for if such period be allowed to pass over without a due supply of nutriment, the lowering of the vital actions, which will inevitably take place in the evening, will offer an insuperable obstacle to any compensating effort being then made. In such cases it must also be clear that the proper time for the administration of remedies is about three hours after each meal, and not at any hour indiscriminately, for then the good effect of the meal will have passed away, and further aid will be welcome. If the mal-assimilation should be accompanied by excessive sensibility of the stomach, the remedy should be quickly repeated, so that more than one dose may be given after the meal and before the next meal is taken; for the interval when the stomach is free from food is manifestly that in which the sedative may act most efficaciously.

203. *Fevers, and similar diseases, having an increase in the evening, require a modification of the natural arrangement.*

204. In fevers we find the natural order of things disturbed, so that in the evening the pulsation instead of falling rises in a marked degree, and the skin,

instead of increasing in activity as the evening advances, loses its power to act and is hot and dry. As the morning hours advance this excitement passes away, and calmness of system, with increased action of the skin and lessened vital changes, gradually appear.

205. The reason for this disturbance of the natural order of phenomena is not quite clear, but it probably results indirectly from, as it is associated with, that law of nature whereby the amount of urea excreted lessens hour by hour as the evening advances; for it has been shown that not only in fever is there an unusually large excretion of urea, so long as the febrile action lasts, but ill effects are produced whenever this free discharge is impeded. And again we find but little or no fever in the early morning, nor until or after midday, viz., at the period when fluid is taken freely, and when there is the most free discharge of urea.

206. Such being the case, it is rational to administer febrifuge medicines in the afternoon and evening chiefly or exclusively,—that is, at the periods when, by the natural course of the system, the excretion would be lessened, for, during the morning, Nature is herself able to effect all that we could wish. Moreover, in the selection of remedies our aim should be to aid the excretion of urea as a primary object, and to increase the action of the skin secondarily, for, in all probability, the latter condition is the resultant of the former.

207. The period for the administration of food and alcohols, in fevers, is clearly in the early and advanced

hours of the morning until mid-day, for then the urea produced may be quickly emitted, but in the afternoon the tendency to the accumulation of urea contra-indicates other remedies than diluents. It will be observed that in this sense purgatives do not meet the requirement, since they may remove excess of carbon, but normally do not eliminate urea.

208. The debility which follows an attack of fever is a totally different condition from that of the fever itself, and requires the application of those remedial methods which have already been described.

209. *In acute inflammation the remedies should be chiefly employed in the middle parts of the day.*

210. In this class of diseases the danger is localised, but it is associated rather with the elevation of the day than the night rate of vital actions in the general system, and it is at the former rather than at the latter period that the greatest progress of the disease occurs. Hence whilst the night periods may almost be left in the hands of nature, the day hours call for active interference. Venesection, for example, would produce very different results as to whether it were performed in the middle hours of the day or the later hours of the evening; and not only would it be far more efficacious in lessening vital action when performed in the former, but in the latter case it might induce danger of a contrary kind by exhaustion. In all instances in the treatment of inflammation, in which venesection is doubtful, it is doubly so in the evening, and the least so in the middle period of the day—

indeed, in our opinion, it could be very rarely justified in the late evening and in the night.

211. The same remarks are applicable to the administration of tartar emetic, or any other powerfully depressing agent.

212. *Apoplexy chiefly occurs after a meal, or in the later hours of the day.*

213. This has already been shown to result from the high rate of pulsation, the lessened action of the skin, and the increased quantity of blood, which occur soon after a meal, and in the afternoon, when there is an excess of nutritive material in the system. But when it occurs on going to bed, or during the night, it results from another condition, viz., the change to the horizontal posture. The periods of prevention are thus indicated, and, as a general rule, they may be said to be limited to the hours of the working day, at which period, almost exclusively, should be applied whatever remedial efforts we may be able to make.

214. *Hæmorrhage is much more liable to occur in the day than in the night.*

215. This results both from the maximum amount of vascular action which is then found, and from the various exciting causes of hæmorrhage, which act during the waking hours, as exertion and coughing. If in the treatment of such conditions it is thought desirable to deplete, it should be done during the day, and the case may be fairly left alone at night; but when the aim is simply to increase the coagulability of the blood, the preventive measures are best em-

ployed in the night and in the early morning, before there is any marked increase in the rate of the functions.

216. *The remedies for the states of exhaustion, as the delirium of inanition or delirium tremens, should be applied chiefly in the evening and during the night.*

217. In this class of affections the symptoms increase in urgency at night, not simply from a supposed alarm at darkness, but from the absence of the day stimuli of food and sunlight, and the great diminution in the force and frequency of the action of the heart. It is the night quantity of vital action which is disproportionately lessened as compared with the day quantity, and the sole aim should be to increase that action. This is effected by food, by alcohols, by opium, and by any other stimulant repeated with sufficient frequency from 7 P.M. until 7 A.M. During the day, after the breakfast hour, it is only necessary to allow the free influence of the natural stimuli if they can be taken.

218. *Nervous affections are commonly the most marked in the evening and during the night.*

219. This is a very well-known circumstance, and it doubtless arises from the fall of the vital actions at these periods, for the predominance of the nervous over the other systems in the body, even although it be temporary, has ever been held to be a mark of deficient power of the body. During the day, when the vital actions are high, when sunlight prevails, and food is often taken, this system is not so prominent in

its manifestations. Hence the remedies required should chiefly be applied in the evening, as the vital powers fail, and in the night when they are at their minimum; and bearing in mind the naturally low state of the system at those periods, stimulants or narcotics will be more efficacious than sedatives, but when nervous symptoms are prominent during the day, with its naturally increased action, it is doubtless better to give sedatives.

220. *The period for the administration of medicines should vary with the known mode of action of each medicine, and the hourly variations in the vital processes of the system.*

221. In applying the foregoing knowledge to a consideration of the proper periods for the administration of the various classes of medicines, it may be objected that as the variations in the vital actions in health are not identical with those in disease, they cannot be accepted as a rule for the exhibition of remedies in disease; but in reply it may be affirmed that, with the exception of febrile conditions, there is no disease which materially disturbs the direction of the vital actions, however much it may intensify or lessen them, and hence that the cases are few in which the principles so often quoted may not be applied in the selection and administration of remedies.

222. *Purgatives* should be always administered at night, for then there is the greatest accumulation of blood, and of carbonaceous or other effete alvine matter. They cannot be administered in the morning

without tending to produce a depression of that amount of vital power which is then one of the prime wants of the system, and without having allowed the continuance of a state of system during the night which was very fitted to prevent that due subsidence of the vital functions which was necessary to repose.

223. *Diuretics* should be administered with considerable frequency in the afternoon and evening, and not in the morning. The kidneys are sufficiently active after the breakfast (if plenty of fluid be then administered), whilst they become hourly less active in the afternoon, and are the least active in the night.

224. *Sudorifics* are called for in the day-time, and directly after each meal, so long as any excess of food shall be found in the system. They are less indicated in the night; and in the early morning they would be injurious.

225. *Stimulants*, when required at all, are especially needful in the early morning and in the evening, whilst during the day they may be much less advantageous. As a rule they should be avoided soon after meals, except in those conditions in which they are presumed to be necessary as local stimulants in the process of digestion.

226. *Sedatives*, when intended to influence the whole economy, are suited to control excess of action during the day, and may then be more freely administered than during the natural period of decline of the vital powers in the advanced evening. It is difficult to understand how they can be required in the evening

and night, except with a view to relieve general nervous sensibility, since, at that period, the vital actions naturally subside to their lowest point without any aid. In nervous cases even it is very probable that a more frequent use of sedatives during the middle of the day would enable them to be dispensed with in the evening and during the night, when Nature should be left to regulate the amount of subsidence of the vital actions.

227. *Narcotics,* having a mixed action, are rather suited to the class of cases where there is unusual depression of the vital powers, and then may be used temporarily at any time, but for a continued action they are more suitably administered in the late evening, since they primarily excite, and by repetition may be restricted to that action.

228. *Chologogues* are more called for in the afternoon and night when the transformation of food is more urgently required.

Diluents and the Cold-water System.

229. There are two objects in the administration of fluids, viz., the solution of the food, and the discharge of effete matters from the body. The former demands that fluid should be taken whenever solid food is eaten, but only in quantity sufficient for the due solution of the solid food. Any defect of this would prevent the introduction of the food into the blood, and any excess of it would weaken the digestive powers. As each kind of solid food demands its

own special quantity of fluid, it is impossible to indicate beforehand the quantity which each person should take, and the appetite for it must be the guide.

230. The importance of diluents in reference to the emission of effete matters is probably greater than is generally admitted, but in health it depends entirely upon the fact of there being an excess or otherwise of nutritive material in the system, and in disease upon the degree of rapidity and intensity of the vital actions.

231. Thus, if in health an individual take an amount of food which is not required by the wants of the system, he will retain to an injurious extent both partially digested material and the result of unusual metamorphosis. After a dinner party, for example, in which a greater variety and quantity of food is taken, and probably more wine drank than is the habit of the individual, there will be an unusual amount of urea eliminated during that night, and probably during two or three days. Thus, in February, we evolved nearly 400 grains of urea per day with ordinary food, but after a dinner party, at which we ate and drank moderately but of unusual food, the urea was increased to 507 gr., 498 gr., and 550 gr., in succeeding days. If in such a state there be free emission of urine, the excess of urea will soon be carried off, and the natural state of the system be restored; but if otherwise, there will be headache, weariness, and other symptoms of what is called a

bilious attack. Now, in the latter case, and indeed in any condition in which it is probable that it will occur, the free drinking of water, or perhaps other diluents, will have the effect of removing a much larger amount of urea than would have been otherwise passed. In a number of experiments made by us this year to determine the effect of drinking a considerable quantity of cold water in the morning (76), before breakfast, we found invariably that an increase in the quantity of urine voided immediately occurred to an extent nearly double of that of the water drank.

232. Thus, in January, after taking 8 oz. of cold water at 9 A.M., 9¼, 8¼, and 8½ oz. of urine were voided at 10, 11, and 12 o'clock, or 25½ oz. before any food was taken. At 12¼ a good meal was taken, consisting of 22 oz., of coffee, bacon, bread, &c.; and from 12 to 4½ P.M. less than 2 oz. of urine per hour were passed. The urea was increased from 15¼ grains per hour to 26, 21, and 20 grains per hour at 10, 11, and 12 o'clock. In February, after taking 8 oz. of water at 8½, 9½, and 10½ A.M. without food, the quantity of urine passed at 9½, 10½, 11½, and 12 o'clock was 12¼, 21½, 16½, and 7 ounces, or 57¼ ounces in 3½ hours, and the urea was increased from 18¾ grains to 27, 26, 26, and 25 grains per hour in succeeding hours.

233. In these instances, it may be readily believed that the free use of water is of the greatest value, and if, in addition, there should be a short fast

from solid food, the body would soon be rid of any excess of urea. Hence, in fevers, the unlimited use of warm drinks is imperatively called for, and they should be taken chiefly in the afternoon and evening.

234. But as to those who do not at any time indulge in excess of food, it may be wisely questioned if the indiscriminate use of large quantities of water, when fasting before breakfast, when the vital actions are low, as practised in some water establishments, and at various spas, is not very fitted to lower the tone of the system; and it is difficult to admit that there can be any good physiological ground for such a practice. Thin and somewhat feeble persons should be advised to avoid such a course of procedure, but the corpulent, and the *bon vivant*, and the gouty, in the vigour of life may undoubtedly be benefited by it.

235. We are aware that it has been attempted to prove the advantage of cold-water drinking by a supposed increase in the vital actions from the loss of heat, such as doubtless occurs from proper exposure of the body to a cooler temperature, or from cold bathing; but the amount of this action is quite insignificant. The defence of the procedure must rest upon the basis now laid down, viz., the removal of any excess of urea or effete matters; and in order that it may have this effect, it is essential that no food whatever be taken with it, or very soon after it. It is also to be understood here that the fluid to be taken for this purpose must be water, or perhaps

other fluids of very low specific gravity, for otherwise it will not be taken into the blood, but will pass off by the bowel, and whilst relieving the body of one kind of effete matter will leave the accumulation of urea untouched.

WEEKLY CYCLE.

CHAPTER III.

SCIENTIFIC RESEARCHES AND THEIR PRACTICAL APPLICATIONS.

236. On a general consideration of our own sensations, and of the various external causes which influence the activity of the functions of the system, we have no difficulty in admitting the occurrence of a daily cycle of vital changes, each returning with regularity as the phenomena of the day appear, and each bearing a close resemblance to those which have come before. The occurrence of a weekly cycle of changes is not so evident; and, in order to prove its existence, it is necessary to consider the subject attentively, for the causes of such a recurrence are not universal, neither do they so readily attract attention.

237. There is a cause for a weekly cycle in the habits of many persons, nearly as efficacious as any which exists in the events of the day, and one which, although acting at distant intervals, is nevertheless very powerful; viz., the institution of the

Sabbath—the long-ordained day of rest to the mental and physical organisation. It is not, however, equally influential in all persons, for as there are many who scarcely labour during the week days, and therefore do not need the physical rest of the Sabbath, so there are many who do not rest on the Sunday, whatever may be the exertion which they make during the week; but in reference to the mass of the inhabitants of this country, there is practically a marked line of distinction between the amount of labour at these two periods, and this having occurred from their childhood, it may be presumed that the weekly cycle of vital changes has been established. This, on *a priori* grounds, will not be denied, for if there be a recurrence of any phenomenon within the system, a condition of periodicity will be established. There are many persons who have attacks of headache from disordered stomach and liver, or of indigestion, or of pain, recurring at tolerably fixed and distant periods, due no doubt to causes which slowly increase, but which ultimately produce noticeable results, and, having subsided, accumulate again, and appear after another equal interval. The mode of living of many persons is so regular in the recurrence of every event, that if any evil arise, and subsequently disappear, there is a probability that it will recur again and again with somewhat similar intervals, and it is only when a change occurs in the conditions which give rise to them that they will vary in their periodicity.

238. Hence, without scientific observation, it might

be affirmed that, when the week is spent in labour and the Sabbath in rest, there will be a progression in the amount of vital change, which will constitute a true weekly cycle. Just as the body and mind are fresh and vigorous in the morning, and fatigued at night, with all the intermediate conditions progressing throughout the day, so we are conscious of freedom and elasticity of thought with power of body in the beginning, and weary sluggishness at the end of the week, with a progressive decline of power and of disposition to exertion as the week advances. The cheerful aspect and elastic step of the workman on the Monday is notoriously different from his jaded appearance at the end of the week, and there are many persons who, with ourself, could point out the approach of the accustomed day of rest, simply by their own progressing weariness. Without doubt we are all conscious of the great differences in our own experience, and, after a hard week's work, long for the occurrence of our day of rest. All this implies that there is less fitness for labour and more exhaustion as the week advances.

239. Experience in the treatment of beasts of burden tends also to the same result. It is well known that a horse worked every day, without intermission, is sooner rendered unable to work, whilst one which has a periodic day of rest—whether once in seven days or in ten days—will not only labour more satisfactorily, but will retain its vigour to a later period of life. Hence we may affirm that the prime

ordinance of the Creator that there should be a periodic day of rest is one essential to the welfare of the animal frame, for in man and animals alike it is found to be beneficial, whilst the neglect of it is proved to be hurtful. With therefore recurring periods of repose and of restoration, there will be induced, on each occasion, a higher degree of vital power than existed at the termination of the previous period of continued labour. With the variation in the intensity of the causes which induce these results, so will the effects vary; and hence we must be content with a demonstration of the two extremes without being at all times able to show a clear line of progression throughout the week.

240. There are four inquiries in which we have been engaged, which more or less directly have reference to this question, and which tend to show that, with diversity of condition of the body on the Sunday from that found during the week, there are certain peculiarities in the vital actions observed on or from that day. These are variations in the rate of pulsation and respiration, in the evolution of carbonic acid and urea, and in the weight of the body.

DIAGRAM. No. 8.

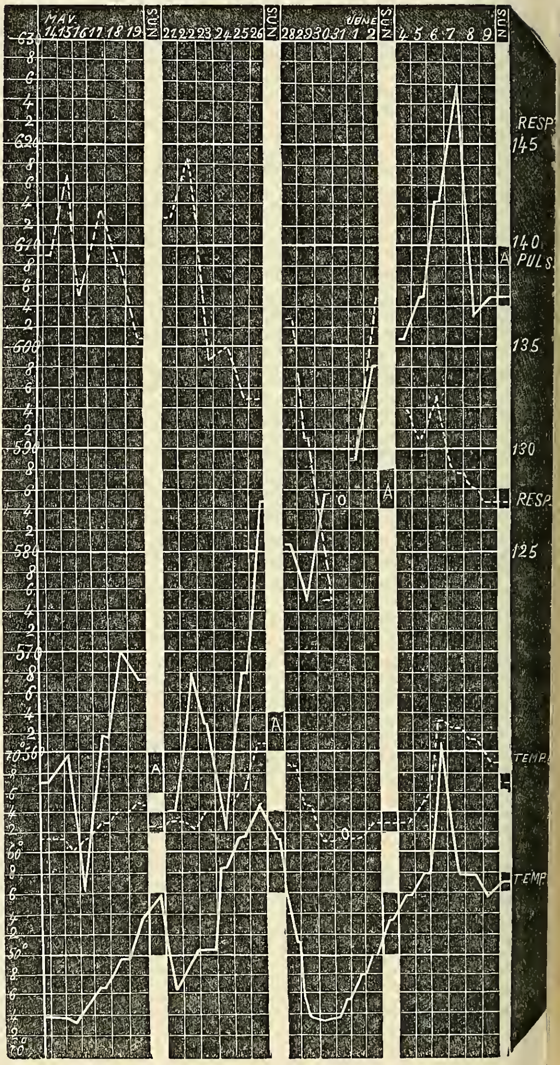


Diagram Showing the Average Daily Rate of Pulsation and Respiration in the three Postures combined, and at two periods of the day in 15 Phthisical Persons, and also the Mean Temperature at Greenwich (temp. ex) and within the Hospital (temp. in) on each Day from May 14 to June 9. The Ascending Lines are those of Pulsation, and the Descending those of Respiration; and in order to obtain the true rate in the sitting posture, the numbers indicated must be divided by 6. The Lines of Temperature are placed at the bottom of the Diagram.

Variation in the rate of Pulsation and Respiration.

241. In the inquiry at the Hospital of Consumption already referred to (36), in which the rate of pulsation and respiration was determined at two periods of the day in 15 consumptive patients, during the whole of the month of June, it was found that in no less than three of the four weeks the rate of pulsation increased through the week, and decreased on each Monday, whilst that of respiration decreased through the week and rose on the Monday. No observations were taken on the Sunday, but it will be observed on the following Diagram that the two sets of lines pursued opposite courses, and changed their direction from the Saturday to the Monday. We have attributed this change to the influence of temperature (279), for it singularly happened that the line of temperature followed that of pulsation, and in three out of the four consecutive weeks it fell from the Saturday to the Monday. How far that should be regarded as the sole cause of the variation in the rate of the function we cannot affirm; but the singularity of the circumstance would lead us to question it. It would, however, under any circumstances show that an influence, acting periodically, is accompanied by periodical effects.

Evolution of Carbonic Acid.

242. The experiments upon this subject will be fully discussed in Chapter V., and they are repre-

sented upon Diagram No. 7. No inquiries were made on the Sunday, but an increase in the quantity of carbonic acid evolved was commonly found on the Monday morning. This increase was doubtless due to an unusual accumulation of nutritive matter, caused by rest, and a little increase in the quantity of food taken on the Sunday, and would therefore be equally present on any other day in which the same condition existed. It is impossible that the habits of any one should permit the same degree of exertion to be made, and the same kind and quantity of food to be eaten on every day alike, but in our case both were tolerably uniform, and the Sunday, as a day of rest, was distinctly marked from any other day; and hence, it will be observed, in Diagram No. 7, that whilst variations in the quantity of carbonic acid evolved occurred very frequently, there was commonly an increase on the day on which M. (Monday) is engraved at the head of the column. The frequency of this occurrence, and the rational explanation of it, can leave no doubt as to its having been due to the special conditions of the Sabbath.

Variation in the Urea evolved.

243. The experiments on the emission of urea will also be discussed in Chapter V., and we shall here only refer to the fact that there was commonly an increase in the evolution of urea on the Sunday, including the day and the following night.

244. We regard the production of urea as in great

part due to the ingestion of food, and in very small part to exertion, and when it occurs in excess in health it indicates excess of food in relation to the wants of the system or the power to appropriate it, and hence a large emission of it on the Sunday night might be reasonably expected. The fact of there being an *increase* on that day will, however, depend upon the conditions of the preceding day, for there might have been less rest and food taken on the Saturday than on the Sunday, and thus lead to a probable increase on the latter day; but since it is not unlikely that, with a diminution of vital force as the week advances, there will be less appropriation of food, an increase in the evolution of urea would occur under that as under the more healthful conditions of the Sunday. We should therefore regard the absolute quantities rather than the relative ones of increase as the best fitted to prove the influence of the Sunday, and we find that on the whole average of the year, to the end of February, 1861, the amount of urea evolved daily was 17 grains more on the Sunday than on the week days—the actual quantities being 523 grains daily on the whole average, and 540 grains daily on the average of the Sundays. When the Sunday is compared with the 191 days in the year on which no known disturbing cause was acting, the excess in the elimination of urea on the former is increased to 67·8 grains daily.

Variation in the Weight of the Body.

245. Variations in the weight of the body at short

intervals are due rather to the retention or emission of fluid, and partially transformed food, than to any increase in the solid parts of the body, and therefore must be associated with the conditions recorded in the preceding sections.

246. When the body was weighed naked, and directly after the emission of urine, it was found that the weight fell as the week advanced, if the conditions of the week had been tolerably uniform; but if the amount of rest and food had materially varied this progression did not occur. The following table gives the result of an inquiry made every night and morning during four weeks, and shows the mean of the weights at night and the following morning:—

TABLE No. 22,

SHOWING THE MEAN WEIGHT OF THE BODY IN POUNDS AND OUNCES AVOIRDUPOIS, PLUS 13 STONES.

	Feb. 4 to Feb. 10.	Feb. 10 to Feb. 17.	Feb. 17 to Feb. 24.	Feb. 24 to May 3.
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Sunday . . .		9 14	9 3	11 1¾
Monday . . .	9 6½	7 10	9 2	9 13
Tuesday . . .	9 7¼	8 7½	10 7¼	9 9
Wednesday . .	9 2	7 12½	9 12½	11 2
Thursday . . .	8 2¼	8 6¾	8 2½	10 4¼
Friday . . .	8 8	8 8¼	8 14	Error.
Saturday . . .	8 8	7 8	8 14¼	9 15

247. The conditions of the body were more uniform

in the two first than in the two last weeks. In the former there was much daily exertion, and the noticeable diminution in weight on February 11 occurred on a day when we entered upon the arduous duty of canvassing, and was due to much exertion and sense of fatigue. In the latter weeks the occupation was more sedentary and less uniform. The remarkable diminution in weight on the Saturday and the great increase on the Sunday are shown throughout the table, and, although the progression is less uniform in the latter than in the former weeks, it cannot be doubted that the table exhibits abundant proof of the facts that as the week advances the weight of the body is lessened, and the system invigorates itself on each Sunday.

PRACTICAL APPLICATION TO HEALTH.

248. *A periodical day of rest is necessary to the well-being of the body if a suitable amount of exertion be made daily.*

249. Whatever may be the full value which should be assigned to the inquiries recorded in the foregoing chapter, it must be admitted that they all tend to show the importance of the day of rest, in limiting undue waste, restoring vital power, and accumulating nutritive material. The rest day is especially valuable to the masses of mankind—to those who sustain much physical labour; and, although our experiments have had no reference to mental exertion, it is highly

probable that the Sabbath is as important to those who think as to those who work. It is not so essential to that smaller section of the community who do not practise either mental or physical exertion with regularity or intensity.

250. The entire exclusion of labour on the rest day is as clearly indicated by our experiments as is the mere diminution of it, and we feel assured that the more rigidly the exclusion is enforced the more will the working-man of all classes benefit by the day. We have the conviction that our capability to labour through the week is essentially connected with the amount of rest obtained on the Sunday, and only when the latter has been profound, or some other period of rest has been obtained, have we been able to fulfil the duties of the week with comfort. Hence it is scarcely possible to attach too much importance to this primeval ordinance—an ordinance copied into almost every religious system, and obeyed, at least in theory, by all civilised nations; neither is it possible to read the very precise and rigid terms in which it is given without feeling that they were warranted, even in reference to the well-being of the body only. The Sabbath is the protector and restorer of the working-man, and in all probability there is a relation between its observance and the powers of working men (112).

251. *Clergymen and others whose duty calls them to labour on the Sunday should set apart another day as a day of rest.*

252. Although it has been shown by our inquiries

that the state of the system on the Saturday is very different from that on the Monday, it is not to be inferred that for the purposes of the body it is important to take rest on one day in preference to any other, for, doubtless, the same circumstances would be found on any other two days if the day of rest intervened. We argue for the necessity of a periodical day of rest without attaching more importance to one day than another; but considerations of a much higher kind have selected the one which is set apart in Christian communities. The clergyman must be engaged on the Sunday—and, indeed, he labours more on that than on any other day—yet his system needs restoration as much as that of any other man. If he diligently labour on the week day, and also on the Sabbath, he is contravening a prime ordinance of his nature, and in doing so must tend to injure his health and shorten his life, and, at the same time, render his labours less vigorous. To this evil must, doubtless, be attributed much of that want of robust health which commonly marks the hard-working minister of religion, and induces the attack of his great foe—the clergyman's sore-throat. No plan can be proposed which shall remedy the evil except the establishment of a day of rest, unless it be shown that a day of rest is unnecessary for man, or that the clergyman's system is alone free from the infirmities of his nature. It is a duty which a clergyman owes to himself and to his office to select Monday for his day of rest, and to enforce the rest of

mind and body on that day as rigidly as is enjoined upon other men in the proper observance of the Sabbath. The idler, whether clerical or laical, may be left to the exercise of his own discretion.

SEASONAL CYCLE.

CHAPTER IV.

OPINIONS OF THE ANCIENTS.

253. The cyclical changes proceeding in the animal economy from season to season are known to common observation, and are eminently capable of scientific demonstration, whilst their external causes are most numerous and striking. We are informed by common observation of such evident and general facts as the phenomena of vegetation, with the progressive stages of budding, growth, maturity, and decay; the manifestation of the sexual appetites in animals, with the shedding and other change in the character of their dermal coverings; and the variations in our sensations, sense of vigour, and general *bien aise*. We are also acquainted with the seasonal migrations of man and animals from the inland region to the sea-coast, or *vice versâ;* from pestiferous lowland to upland places; from a hotter to a cooler climate or locality, or *vice versâ;* or from one locality to another in search of food, as in the case of the inhabitants

of the Arctic regions. Moreover, popular belief has universally attributed varying degrees of healthfulness to the changing seasons — as, for example, the spring and fall of the year—so that the former is believed to be the most healthful, and the latter the most prone to induce disease, and household medicines of a prophylactic tendency are then administered. Special kinds of disease are also known to be unusually liable to occur at each season —as chest diseases in the winter, bowel affections in the autumn, and eruptive diseases in spring. Indeed there is perhaps no subject which influences the conduct of mankind so much as the instinctive knowledge and common observation connected with season; and possibly it is to the very perfection of our instinctive guide that so little need has seemed to exist for exact scientific research upon the subject.

254. It is worthy of remark that, whilst the ancients gave great attention to matters of common observation, and collected numerous and important facts connected with this subject, we seem to have wilfully shut our eyes to the light presented to us, for in no work of our own day do we find any observations of a general kind as to the influence of season; neither has the high characteristic of our times been brought to bear upon it—viz., the faculty for scientific research.

255. It is almost impossible to turn over the pages of the medical fathers, without finding how much importance was attached to season in the production

and cure of disease, or without admitting that the information which they have handed down to us is true and applicable to our own era. We do not purpose to enter at any length into the history of this department of knowledge; but we think that it will be instructive to notice with what extent and accuracy the influence of season was known to Hippocrates, as is shown in the twenty-four Aphorisms which he has transmitted, and which have been so ably edited for us by Sprengel,[1] Adams, and Clifton.

256. The division of the seasons has varied with different nations and eras, and has been arbitrary, except so far as it was associated with the occurrence of certain natural phenomena more or less general or peculiar to the locality. We find that in the most ancient periods the Egyptians[2] divided the year into three seasons, viz., the "Season of Vegetation," the "Season of Manifestation," and the "Season of the Waters," or the "Inundation;" and at the present time the first is called "Winter," the second "Summer," and the third "Inundation," or literally "The Nile." This division was associated with terrestrial changes; but in ancient Greece it was determined by astronomical phenomena, as it is with us at the present day.

257. Dr. Adams informs us that with the ancients *Winter* began at the setting of the Pleiades, viz., the period when they set with the sun, and continued

[1] Aphorisms of Hippocrates, by Dr. Sprengel. London. 1708.

[2] Horæ Egyptiacæ. 1851.

to the vernal equinox. *Spring* commenced at the last-mentioned period (the vernal equinox), and ended at the rising of the Pleiades, viz., the rising with the sun. *Summer* began at the rising of the Pleiades, and continued to the rising of Arcturus; and *Autumn* extended from the rising of Arcturus to the setting of the Pleiades. Thus the division of the seasons was purely astronomical, and the constellations of the Pleiades and Orion were the dividing objects; the rising of the Pleiades with the sun separating the first from the second half of the year, and the setting of the same constellation with the sun terminating the year.

258. Having thus defined the several seasons, we will now, in a few words, give a condensed account of their influence as gathered from the opinions of Hippocrates, expressed in the "Aphorisms" above mentioned.

259. Change of seasons, and the alternations of cold and heat in those seasons, are most effectual causes of diseases. Some natures are well or ill affected in summer, and some in winter. Some diseases and some ages are well or ill affected at different times of the year, &c.

260. Autumnal diseases may be reasonably expected when on the same day it is sometimes hot and sometimes cold. The south wind dulls the senses of hearing and sight, causes headache, heaviness, and faintness. When it prevails these incidents occur to the weak and sickly. The north wind affects the chest and throat, and causes constipation, dysuria,

and muscular pains. The south wind relaxes, and the north wind contracts the tissues of the body. When the summer is like the spring (viz., cool and wet), we must expect much sweating in fevers. Dry seasons are the cause of sharp fevers.

261. Constant and seasonable times of the year are accompanied by diseases which are regular and mild, but in inconstant and unseasonable times the diseases are uncertain and difficult of cure.

262. In autumn diseases are most acute and pernicious, and that season is hurtful to those in consumption. Spring is most healthy and free from fatal disease. If the spring be rainy with southerly winds, and have followed a dry and cold winter, there will be in the following summer acute fevers, catarrhs, and bloody discharges. With a dry and northerly spring, following a rainy and warm winter, there will be bloody discharges, ophthalmia, rheumatism, and catarrhs, fatal to old people. Abortions easily arise under these conditions, and children thus born near the spring are weak and diseased, and either grow up so or die quickly. A rainy and warm (southerly) autumn, following a dry and cold (northerly) summer, will produce in the winter pains in the head, cough, catarrhs, and consumption. A dry and cool (northerly) autumn is good for those of a moist temperament, but to others it produces ophthalmia, acute and lingering fevers, and melancholy.

263. Great droughts are more wholesome and less destructive than continual rains and frequent showers.

Continual rains cause most diseases, as lingering fevers, diarrhœa, diseased humours, falling sickness, and apoplexy. Great droughts occasion consumption, inflammation of the eyes, rheumatism, incontinence of the urine, and bloody discharges.

264. Continued northerly weather braces and strengthens the body, makes it agile, fresh coloured, and quick of hearing. It restrains the bowels, increases chest-pains, and offends the eyes. Southerly seasons relax and moisten the body, dull the sense of hearing and sight, cause heaviness, vertigo, laziness, and diarrhœa.

265. Children and very young people have good health in the spring and the beginning of summer; old people in summer and some part of autumn; people of middle age in autumn and winter.

266. All diseases appear at all seasons, but some are caused and exasperated rather in one than another. In the spring affections of the brain, falling sickness, discharges of blood, affections of the throat and chest, diseases of the skin, and rheumatism. In summer some of the above; also burning fevers, agues, disorders of the stomach and bowels, violent sweatings, and affections of the eyes, ears, and mouth. In autumn many summer diseases, also fevers, enlargement of the spleen, dropsies, consumption, asthma, diarrhœa, and dysentery; Iliac passion, falling sickness, and brain diseases.

267. These statements of Hippocrates evince great sagacity and extent of observation in the physicians of

those distant times, and well merit our careful consideration; but as some of the expressions are not familiar to those living at this period, we invite attention to Dr. Sprengel's comments. We shall now proceed to consider the details of modern scientific research.

SEASONAL CYCLE.

CHAPTER V.

SCIENTIFIC RESEARCHES.

268. We have made the subject of the influence of season one of extensive and long-continued inquiry, extending from the early part of 1858 to the same period in 1861, the earlier researches embracing inquiries into the influence of season upon the evolution of carbonic acid, the quantity of air inspired, the depth of inspiration, and the rate of pulsation and respiration, whilst the latter determined the elimination of urea, water, and other excretions. We purpose to state the principal results obtained upon each of these subjects of inquiry.

Carbonic Acid expired.

269. In 1858 and 1859 we determined the amount of carbonic acid exhaled by two healthy persons at the same hour, under the same conditions, and in the complete absence of exertion, food, and every other known cause of variation, except season. The apparatus and method employed were those already

described (44), and the experiments were made before breakfast on succeeding mornings, from March 31, 1858, to the same period in 1859. In each experiment the carbonic acid was collected during a period of five minutes. The results obtained were very definite, and have such an agreement in the lines of their progression, that full confidence may be accorded to them.[1]

270. The tabular returns obtained are so large that it would be inconvenient to insert them here; but they are delineated on Diagram No. 7, extracted from the "Philosophical Transactions." On a careful examination of this diagram, it will be observed that there was a definite variation in the amount of vital action proceeding within the body at the different periods of the year, and that this followed a well-marked course. Thus, at the beginning of June (up to which period the amount of vital action had been very high), we found a fall to commence, and this continued and progressively increased through June, July, and August, until the commencement of September, when the lowest point was attained. After this period, viz., in October, an upward tendency was manifested, and it continued through October, November, and December, until January, when a point was attained from which there was little variation through January, February, and March. In April and May the amount of carbonic acid evolved was yet further increased, until the point was reached whence we started. The extreme amount of

[1] Phil. Trans. 1859; and Med. Chi. Transac. 1859.

change observed was a loss of 3 grains of carbonic acid per hour (or $\frac{1}{3}$ of the maximum quantity) from the commencement of June to that of September; a gain of 2 grains and upwards from September to January; and a further gain of half a grain to the maximum period of the year. The extreme quantities recorded were, in ourself, 10·26 grains on May 31, and 6·76 grains on October 4; and in Mr. Moul (whose experiments terminated in June), 9·36 grains on April 3, and 5·71 on June 4.

271. The monthly averages enable us to appreciate the progression of the changes more readily than the voluminous records of the daily observations, since the eye can follow the progression of the series at a glance, but they have the disadvantage of representing only the means of all the quantities obtained. We have collected these monthly means on all the subjects of inquiry, and have inserted them in the following table, to which we shall have occasion repeatedly to refer.

272. From the first column in the Table No. 23, we find that there was a progressive diminution in the quantity of carbonic acid evolved from April to September, and thenceforward an increase, progressing through October to January, and reaching a point which was stationary in the following months. The month of highest returns was May, and the next one was April; and the average increase from the winter months, when the inquiry ended, to the spring months, when it began, was somewhat more than half a grain

TABLE No. 23.

Monthly Averages of the Amount of Carbonic Acid Evolved, and of Air Inspired, with the Rate of Pulsation and Respiration, &c., in 1858 and 1859.

	Per Minute.				Temp.	Bar.
	Carb. Acid. Grains.	Air Inspired. Cub. In.	Pulsation.	Resp.	°	inches.
Ourself.						
1858. April . .	8.58	498	72·8	14.3	54·5	28·84
May . .	8·89	451	68·3	12·4	58·1	29·51
June . .	8·19	426 .	71·1	11·64	71·7	29·61
July . .	7·62	393	69·8	11·	65·1	29·48
August .	7·15	392	73·3	10·9	66·6	29·49
September .	7·13	402	66·6	10·94	61·2	29·51
October .	7·67	395	69·8	10·93	52·8	29·38
November .	7·86	414	69·1	10·87	43·8	29·28
December .	8·27	429	67·	11·15	45·2	29·43
1859. January . .	8·35	447	68·8	11·73	43·1	29·64
February .	8·2		69·2	11·35	46·3	29·58
March . .	8·25		70·9	11·38	48·9	29·47
Mr. Moul.						
1858. April . .	7·18	429	80·3	15·6		
May . .	6·63	384	82·1	12·75		
June . .	6·34	367	79·9	12·6		

per minute. The average amount of the whole year, evolved at rest and before breakfast, was a little over 8 grains per minute.

273. From the whole of the foregoing statement we learn that in the summer season the amount of

chemico-vital change progressively lessens, until the period arrives when there has been the greatest accumulation of heat upon the surface of the earth; in the autumn there is a progressive increase, by which two-thirds is gained of that which had been lost in the summer months; in the winter the amount is tolerably stationary, and varies scarcely more than half a grain per minute, whilst in the spring there is the highest amount of vital action observed during the whole cycle of the year.

274. The periods of the greatest variation in the evolution of carbonic acid in the foregoing inquiry were June and July with decreasing vital actions, and October and November with increasing changes, and those periods may be aptly designated as "decreasing" and "increasing" respectively; whilst the end of July, the whole of August, and part of September were the "minimum" periods, and the true winter and spring months the "maximum" periods. The two former may further be recognised as "variable," and the two latter as "fixed" periods. In the particular inquiry now under description, these various periods may be tabulated as follows; but it will be readily understood that they will vary within narrow limits with the precise character of the seasons of each year:—

Fixed.	Variable.
Greatest { Jan., Feb., March, April, May, (July,)	Decreasing.—June, (July).
Least.—Aug., part of Sept.	Increasing.—Oct., Nov., Dec.

Air inspired.

275. The quantity of air inspired day by day is represented in Diagram No. 7, and the monthly averages in Table No. 23. The average amount at the periods of observation was 425 cubic inches per minute; but the extremes recorded were 588 cubic inches on April 12, and 363 cubic inches on July 13. The progression in the quantities obtained followed closely that already recorded in reference to carbonic acid, so that they declined from April to July, August, September, and October, and thenceforward increased; but it will be observed that the minimum period was much more extended than that observed in reference to the carbonic acid.

Relation of the Air inspired to the Carbonic Acid expired.

276. There is a very close relation in the amount of air inspired and of carbonic acid expired, as was proved both by these and other extended inquiries in reference to their mutual correspondence and their common dependance upon external causes; and although the relation is not so absolute that the one may with rigid exactness be inferred from the other, it is so close that for all practical purposes the proposition may be affirmed, that as is the quantity of air inspired in natural respiration and at rest at the same period of the year, so will be the amount of carbonic acid exhaled. But there is a limited change

in this relation observed with the change of the seasons, as there is also under the conditions of fasting and exertion already referred to (95). In our case it was recorded that as the summer advanced there was a diminution of 30 per cent. in the quantity of air inspired, and 32 per cent. in the rate of respiration; but it was only 17 per cent. in the rate of carbonic acid exhaled. This, however, is chiefly found in the later or "minimum" months; for in the spring months it was proved by experiments upon Mr. Moul that up to the middle of June the loss in each of the subjects of inquiry was almost identical, viz., 27 per cent. in the quantity of air and carbonic acid, and 28 per cent. in the rate of respiration.

277. Hence the two phenomena of the volume of air inspired and the amount of chemical change induced are correlative facts, and have the same significance.

278. This variation in the effects of the summer from that of other periods of the year is one of the most striking results of the inquiry, and will be again referred to when we discuss the relation of temperature to their seasonal effects.

Rate of Respiration.

279. The progression in the rate of respiration followed that of the quantity of air inspired more closely than that of the carbonic acid exhaled, but in all three there was a marked agreement. It declined

from a monthly average of 14·3 per minute in April to 10·9 per minute in August, September, October, and November, when we find the singular fact, that through so long a period as three months the average varied only in the second place of decimals, and in the fourth month the minimum of 10·87 per minute was attained. The rate thenceforward increased, but did not nearly reach the amount recorded in the previous April.

Rate of Pulsation.

280. We have now to refer to a subject of inquiry in which the progressive changes are somewhat opposed to those which have now been discussed. It will be observed in Diagram No. 7, and Table No. 23, that the rate of pulsation remained very high during the summer months, and, indeed, reached its average maximum of 73·3 per minute in August. The difference in the average maximum and minimum rates was but small, viz., 5·7 pulsations per minute; and it is singular that these two conditions should have been found in two consecutive months, viz., July and August: but it will be observed that the increase which followed the latter month was not considerable. The extremes in the rate of pulsation were 80 and 64 per minute; yet as the former occurred but once, and the latter twice, they do not give any exact idea of the true variation in the rate.

Relation of the Rates of Pulsation and Respiration.

281. The inverse relation of the two series of phenomena just referred to—viz., the rates of pulsation and respiration—is not due to correlative causes, but to diverse circumstances. The rate of respiration has been shown to follow the course of the other phenomena of respiration; and, like them, is indicative of variation in the amount of chemical action: but the rate of pulsation is chiefly influenced by the degree of activity of the skin and the necessity for the abundant transmission of fluid for evaporation. It is a common error—both professional and laical—that the skin and lungs exert a mutually compensating action, so that when the one fails, it is supposed to be the duty of the other to take on an increased action by way of maintaining a due balance in the economy. This has resulted from a comparison of the two facts, that when the skin is perspiring the respiration is quiet, and perhaps feeble; whilst, when the former is hot and dry, as in fever, the latter is hurried. But a moment's consideration of the structure of these two organs would suffice to show that they cannot have a common action; and that whilst the function of the lungs, *par excellence*, is to aerate the blood and to evolve carbonic acid, the action of the skin is to cool the body and to eliminate water.

282. It is true that the skin throws off carbonic acid and certain volatile acids which are rich in carbon; but we have proved that in ourself the former does not exceed 6 grains per hour in the

summer months, and the amount of the latter is quite inappreciable when compared with the quantity of carbon evolved from other parts of the body.

283. The inverse relation of the rates of the two functions was well exemplified in the inquiry on consumptive patients, before referred to (241), in whom the rate of pulsation progressively increased during the whole month of June, whilst that of respiration as progressively decreased. The Diagram on page 122 shows the directions of the two sets of lines illustrating these facts, and how striking is the contrast which they exhibit. It is prepared from the combined numbers of pulsations and respirations in the three postures of lying, sitting, and standing, and at two periods of the day, so that the total quantities are six times more than an average of the whole. The results were obtained from fifteen persons, and the sum of the observations exceeded 1500; yet on this great average the total average pulsation was 93, 93·6, 97·6, and 101.5 per minute in the consecutive weeks.

284. But whilst there is not an immediate common cause for this diversity in the rate of these two important functions, there is one common result, viz., a marked tendency to a reduction of the vital powers, for so surely as the blood is more perfectly decarbonised by frequent and deep inspiration, and moderately slow pulsation, so surely is it imperfectly purified by rapid pulsation and slow and feeble respiration.

Urea and Water evolved by the Kidneys.

285. The series of inquiries in which the determination of the amount of urea and water evolved by the kidneys was ascertained, has already been described (58). It was commenced in January, 1860, and terminated in March, 1861, and comprised numerous analyses, made daily throughout nearly the whole of that period. The year 1860 was remarkable for the great variations of temperature, and particularly for the coldness of both the summer and the winter seasons, and hence it was not well fitted for the determination of the effect of marked summer weather. During this inquiry, the ordinary mode of living was continued, and an accurate record kept of all the ingesta and egesta; and the amount of exertion was that which was necessary for our daily pursuits. Hence the changes recorded will be due to many combined influences; but they will represent those naturally proceeding in a person of middle life, of full height, in good health, of active habits, of moderate indulgence in food, and of almost total abstinence from alcoholic liquors.

286. We do not purpose at the present time to analyse minutely the voluminous returns which have been obtained, or to enter into any elaborate statement of the causes of the variations which have been recorded, for the period which has elapsed since the completion of the inquiry does not permit the former, and the want of accurate knowledge amongst physiologists as

TABLE No. 24.

MONTHLY AVERAGE OF UREA AND URINARY WATER, &c., IN 1860 AND 1861.

	No. of days.	Daily.		Urea in each oz. of Urine.	Means at Greenwich.	
		Urea. Grains.	Urine. Fl. Oz.		Temp.	Bar.
1860.						
March . . .	13	462	51·16	9·03	41·1	29·655
April . . .	28	489	54·42	9·0	42·9	29·796
May . . .	28	547	45·53	12·02	53·8	29·746
June . . .	32	549	53·03	10·3	54·8	29·613
July . . .	28	505	55·3	9·1	57·6	29·845
August . .	14	646	60·1	10·7	57·7	29·556
September . .	6	665	64·6	10·3	53·4	29·761
October . .	16	518	56·	9·02	50·6	29·856
November . .	13	455	51·7	8·8	40·8	29·696
December . .	30	451	50·17	8·9	36·3	29·491
1861.						
January . . .	28	475	47·87	9·9	32·7	29·706
February . .	28	515	52·9	9·73	41·2	29·959
March . . .	21	472	53·8	8·77	42·7	29·984

to the true indications of urea forbids the latter; but we hope elsewhere to discuss the subject at length. We shall therefore simply state in Table No. 24 the average amount of urea and water excreted during each month, from March, 1860, to March, 1861, with the means of the meteorological changes recorded at Greenwich at the same periods.

287. Nothing could appear to give more definite

results than those which are contained in the above table. With the exception of a depression in the month of July, there is an unbroken line of increase in the quantity of urea evolved per day from March to September, and a total average increase of 200 grains per day. In October we find a considerable decrease, and this progresses yet further through November and December, and thenceforward the quantity bears a very close analogy with that recorded at the beginning of the year 1860.

288. It is thus established that in the ordinary conditions in which we live, there is a progressive increase in the evolution of urea as the spring advances, and throughout the summer, until the autumnal months, when the amount corresponds very much with that evolved during the winter. It appears, therefore, that the year may be more conveniently divided into two than into four parts, in reference to this fact; the former comprehending the spring and summer, which is the maximum period, and the latter autumn and winter, which is the minimum period. The difference in the average amount evolved in these two periods is most striking, viz., in the maximum period, May to October, both inclusive, 570 grains; and the minimum period, November to April, both inclusive, 480 grains per day.

289. The progression in the quantity of urinary water is very similar to that now recorded in reference to urea. There was a noticeable diminution in the month of May, and a considerable uniformity in

April, June, and July; but there was a progressive increase from March to September, when the maximum was attained, and an average increase was recorded of 13½ oz. per day. From the latter period there was a progressive decrease, with a minimum in the month of January, when the decrease from the maximum was 17 oz. per day.

290. Hence it is proved that in spring and summer there is a much larger elimination of urea and urinary water than occurs in winter. There is a very close correspondence in the mutual relation of these two elements, in reference to season; but the proportion of the one to the other is not quite so close, although the same general facts are elicited from both. The average proportion was 10 grains of urea in each ounce of water, whilst the minimum was 8·8 grains, and the maximum 12 grains in each ounce.

291. Without discussing the question of the origin of urea, it is impossible not to notice how directly opposed is the action of season in the production of carbonic acid and urea, the former decreasing, and the latter increasing, in the summer season. The amount of vital action which exists with the decline in the quantity of carbonic acid must certainly be less than exists at other periods of the year, and hence the relation of the production of urea to the assimilative changes, or to other vital actions, receives new light by the comparison now offered.

292. From the foregoing inquiries, we may observe that there are two sets of relations which it is

interesting to bear in mind, viz., the relation between the quantity of carbonic acid exhaled, the amount of air inhaled, and the rate of respiration, on the one hand, and that between the rate of pulsation, urea, and urinary water, on the other.

Causes of Seasonal Change.

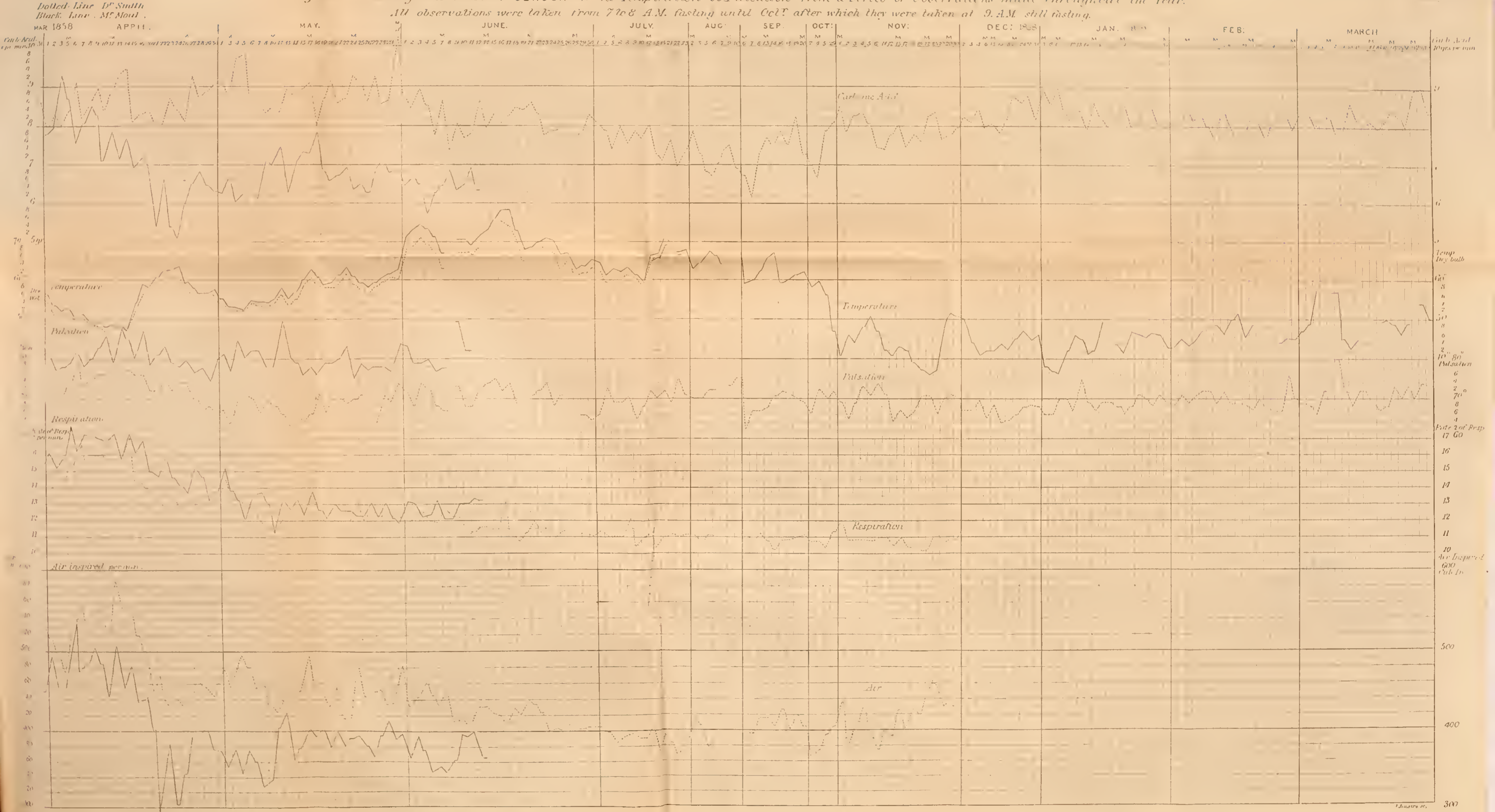
293. We will now glance at the influence which two meteorological phenomena—viz., temperature and pressure of the atmosphere—have been proved to exert over the two principal excretions now investigated.

294. *Temperature.*—Temperature, in reference to the production of carbonic acid, acts manifestly in two modes.

295. Sudden changes of temperature produce equally sudden changes upon the amount of carbonic acid exhaled. This was well shown from the 13th to 27th of April, 1858 (Diagram No. 7, and Diagram No. 5, Figs. 2 and 3), in which there was a sudden and remarkable elevation of temperature, from 47·5° to 63·6° by a continuous movement in seven days, and then a sudden decline to 59°, 58°, &c., on the following days. On the same day that the first increase took place the quantity of carbonic acid exhaled per minute fell from 9·46 grains to 8·14 grains per minute, and continued just above 8 grains until the day on which the temperature fell, when it rose to 9·3 grains per minute. Hence there was a most evident effect produced upon the respiration, and the effect increased in *an increasing ratio.* This

Diagram Shewing the effect of SEASON on the Respiration & Pulsation from a Series of Observations made throughout the Year.

All observations were taken from 7 to 8 A.M. fasting until Oct.r after which they were taken at 9 A.M. still fasting.



change for each degree of temperature varied from ·18 to ·04 grains, as is shown in Diagram No. 5, Fig. 2.

296. On a long average period, such as constitutes a season, the effect of temperature was very marked, but it failed to account for the great variations which were observed, and it was abundantly proved that with the same temperature in the spring and at the end of summer the amount of carbonic acid evolved was far less at the latter than at the former period. That mere degrees of temperature will not suffice to measure the results may be seen by noting the quantities evolved in various months with the same temperature, as for example, 59°, when the quantities were 8·11, 9·13, 7·64, 7·3, and 6·76 grains per minute, in April, May, July, September, and October, in their order.

297. When the line of declining vital changes already given is compared with that of temperature, it is readily seen that as the temperature increases the vital actions decline; and so, on the other hand, in the autumn as the temperature decreases the vital actions increase. But it is of importance to notice that the vital changes continue to decline at the end of summer long after the maximum temperature has passed over. Hence, whilst there is a period of correspondence in the degrees of heat and the quantity of carbonic acid, which is well marked, there is, later, some diversity.

298. It is well known that heat continues to accu-

mulate upon the earth long after the period when the heat of the sun's rays has begun to decline, and that with this heat there is a very marked dryness of the atmosphere; but it has not been shown that these altogether account for the progressive subsidence in the vital phenomena now noticed. The variations in the line of temperature generally preceded those of respiratory changes, and the latter also continued for a time after the first cause had ceased to act.

299. On the whole, it appeared that a medium degree of temperature, such as is pleasant to the body at all periods of the year, might be accompanied by any variation in the amount of carbonic acid, if the different seasons of the year were considered together, but when the temperature rose above that point—say, 60° or 62°—or fell below it, the characteristic effects became evident upon the vital functions. Hence temperature at one season was associated with a different effect upon the carbonic acid exhaled from the same influence at another season; and with a medium temperature it is impossible to judge of the amount of carbonic acid exhaled, unless the season be also indicated. For a fuller investigation into this question we refer to page 706, Phil. Trans., 1859.

300. The influence of temperature over the production of urea may be ascertained in a general manner by reference to Table No. 25.

TABLE No. 25,

Showing the Average Daily Quantities of Ingesta and Egesta in each Month of the Year, compared with the Temperature and Atmospheric Pressure.

Date.	Ingesta.		Egesta.			Greenwich Means	
	Fluids. Fl. oz.	Solids. Oz.	Fæces. Oz.	Urine. Fl. oz.	Urea. Grains.	Temp. °	Bar. Inches.
1860.							
March .	52·25	40·5	4·99	51·16	462	44·2	29·467
April .	54·02	40·	4·49	54·42	489	42·9	29·796
May .	53·53	37·5	5·22	45·53	547	53·8	29·746
June .	58·76	35·5	4·92	53·03	541	54·8	29·613
July .	56·86	37·	4·6	55·3	505	57·6	29·845
August .				60·1	646	57·7	29·556
Sept. .				64·6	665	56·	30·023
October		35·75		56·	518	50·	29·791
Nov. .				51·7	455	40·35	29·537
Dec. .				50·16	451	36·3	29·491
1861.							
January		33·25	7·15	47·87	475	32·7	29·706
Feb. .	54·7	38·	5·56	52·9	515	41·2	29·959
March .	61·1	37·	5·62	53·8	472	42·7	29·984

301. This table shows that as the summer advanced and the temperature rose, the amount of urea increased, so that the year being divided into two periods, that from May to October was accompanied by an increase of 90 grains of urea daily more than was found in the colder half of the year from October to April. The months of marked increase and

decrease of temperature were also those of marked increased and decreased elimination of urea. In the instances of sudden changes of temperature it was found that there was some variation in the effects upon the excretion of urea, but usually the increase was deferred until the following day. This is shown in Table No. 26, in which the quantity of urea evolved is placed under the same and the preceding day.

302. *Barometric Elevation.*—The pressure of the atmosphere had also a considerable degree of importance in reference to the evolution of carbonic acid; but, like temperature, it acted only when it exceeded or fell below the ordinary standard. With ordinary pressure there was found every variation in the vital changes. The relation was an inverse one, so that as the barometer rose the carbonic acid fell.

303. Table No. 25 also shows that there is a close relation between the elimination of urea and the pressure of the atmosphere, and that both increase and decrease together. The Table No. 27 gives an illustration of the parallelism of the two lines of barometric height and urea eliminated in a remarkable sequence of nine days.

304. Hence the relation both of temperature and barometric pressure to urea is *direct*, and their mode of action is probably associated with increase of food or with temporary increase in the elimination of the urea already formed. When these two agents move in opposite directions they lose their distinctive power.

SHOWING THE RELATION OF THE EVOLUTION OF UREA TO TEMPERATURE.

	November.									
	15	16	17	18	19	20	21	22	23	24
Temperature . .	45·8°	42·6°	48·3°	36·6°	37·8°	41·1°	41·7°	43·5°	37·6°	
Urea.—Grains same day . . .	457	478	433	485	413	428	446	489	548	403
Urea. — Grains on succeeding day .	478	433	485	413	488	446	489	548	403	

TABLE No. 27,

SHOWING THE DIRECT RELATION OF THE ELIMINATION OF UREA WITH THE PRESSURE OF THE ATMOSPHERE.

	December, 1860.								
	11	12	13	14	15	16	17	18	19
Barometer . . Inches.	29·528	29·880	29 981	30·120	30·113	29·811	29·513	29·414	29·289
Urea . . Grains.	420	445	530	561	554	526	498	473	401

Summary of Seasonal Influences.

305. It may be advantageous, before closing the present chapter, to indicate in a summary manner the special conditions of the system which have now been shown to exist at the different seasons of the year, and which will be again considered in the succeeding chapter.

306. *Summer.*—The summer season exerts the most marked power, and under its influence the body exhibits the following minimum and maximum conditions.

307. There is the *minimum* of carbonic acid and vapour exhaled, of air inspired, of the rate and force of respiration, of alimentation and assimilation, of animal heat generated, of muscular tone and endurance of fatigue, and, in general, of resistance to adverse influence.

308. There is the *maximum* of the rate of pulsation, of the action of the skin, and the elimination of vapour, of the dispersion of heat, of the supply of heat from without, and of excess of heat, of the elimination of urea and urinary water, of the distribution of blood to the surface, of the imbibition of fluids, of relaxation of the tissues, and of poverty and carbonisation of the blood.

309. *Winter.*—In the winter season the above conditions are, for the most part, reversed.

310. *Autumn.*—Autumn is marked by the summer or the winter condition, as the character of the season

resembles the one or the other; but it is essentially a period of change from the minimum towards the maximum of vital conditions.

311. *Spring.*—In the early and middle parts of the spring season every function of the body is in its highest degree of efficiency, but as it advances these maximum conditions merge into those of summer.

312. Hence the effect of season is more than the physical phenomena of temperature and atmospheric pressure explain, and is so universal that even the same amount of exertion made at two different seasons produced different degrees of effect upon the vital changes—less carbonic acid being evolved from it in summer than in winter in proportion to the relative amounts when at rest at those two periods.

SEASONAL CYCLE.

CHAPTER VI.

APPLICATION TO HEALTH AND DISEASE.

313. We shall now proceed to consider the foregoing inquiries in their application to the maintenance of health, and the production and cure of disease, and to show in what degree they are capable of explaining the actual practice of mankind. In doing this we shall not attempt any systematic arrangement of the subjects to be discussed, but shall consider them as independent facts to be equally well considered in any order that may occur to the mind. We purpose to discuss the influence of season upon muscular power, sensibility, viability, growth, food, disease, and medical treatment.

Muscular Power.

314. *The muscular force and power of endurance of the body varies with the season, and the least is found at the end of summer or the beginning of autumn.*

315. It is not easy to separate the two questions of muscular power and endurance, for in all the exhibitions of force which we ordinarily see the two are conjoined. The diminution of force alone in summer may be inferred from the relaxation of all the tissues which then occurs, as seen in such thin layers as those of the dartos. The cab-horse with its ordinary labour, and the hunter, racer, or courser in the field, with their panting hollow flanks, relaxed limbs, hanging head, and reeking skin, show clearly how much more they suffer when labouring under a hot sun than in the temperate cold of winter. But it is the most certainly tested in the case of the prisoners condemned to the tread-wheel. The ordinary rate of ascent on the tread-wheel is 54 steps of 8 inches each per minute, and during the winter season this may be performed without any evident exhaustion, unless the period of the exertion be too prolonged—as, for example, beyond a quarter of an hour's continuous labour; but in the summer it has been found by experience that this rate of ascent cannot be maintained, and it is universally reduced to 48 or 50 steps per minute. Nothing can prove our proposition more convincingly than this, for the power required is the same at all seasons, the diet and all the general regulations of the prison are the same, and, moreover, there is a natural disposition in all officials to avoid any special alterations in their arrangements which are not thrust upon them in a manner not to be neglected, and in this particular they have no

scientific rule or authorised directions to guide them, but are left to the dictates of their own observation and humanity.

316. But every man has abundant evidence in his own person that he is unable to endure any severe bodily labour with the same facility in summer as in winter.

317. *The causes of the diminution in power and endurance are four, viz.:—The rapidity of the circulation, the difficulty of maintaining a fixed temperature, lessened chemical action, and relaxation of tissue.*

318. *Rapidity of Circulation.*—It has been shown that in summer the rate of pulsation is increased, and hence it will follow that any act by which the pulsation is further increased will the sooner bring the rate to that point at which the circulation will become impossible, especially when to this is added the increased sensibility of the system to be presently mentioned. Exertion is by far the most powerful known excitant of the circulation. Thus with the pulsation at 70 per minute in the quiet standing posture, it was increased to 120 or 130 when walking at full speed (say 4 miles per hour), to 130 or 150 when walking upon the tread-wheel, and 170 to 200 per minute when running at full speed. We have therefore no difficulty in comprehending the fact, that with this rapidity of increase in the circulation a period must arrive when the heart cannot perform its function, or the veins transmit the return current of blood, or the

lungs pass the blood with sufficient rapidity, and then exertion must be brought to a close; neither is there difficulty in admitting that this power of endurance will be lessened in the summer when the pulsation is thus normally quicker, the system more sensitive, and the movement of the lungs lessened.

319. *Excess of Temperature.*—The difficulty of preventing excess of temperature in the summer has been already discussed, and in proportion as exertion (the great exciter of chemical action) is made so will this difficulty increase. In the winter we run or labour to keep ourselves warm, and we thus not only increase the amount of heat developed within the blood, but we send a large volume of hot blood to the superficies to supply the heat which the external air abstracts from it. But in summer we are hot enough without exercise, and when exertion is made, the amount of heat furnished becomes in excess, and requires to be carried off by perspiration. Hence with summer labour we perspire more profusely, and in proportion to the dryness of the external air, by which the vapour may be removed from the surface of the body —to the healthy state of the skin, whereby fluid can be vapourised rapidly—and to the ease with which the heart can convey blood in sufficient amount to yield this large quantity of water without seriously varying its own composition—so will this excess of heat be dispersed, and the immediate cause of it be tolerated. But with so many necessary conditions there will be so many dangers, and with exertion a limit is soon

arrived at, beyond which the high degree of temperature cannot be borne with impunity.

320. *Lessened Vital Action.*—The two former influences are the most powerful agents in this inquiry; but their action is chiefly restricted to the exhibition of force which approaches the limits of exertion which the individual can at any time bear. It is, however, equally true that more moderate labour is not so well borne in summer as in winter, and this is in a great degree owing to the influence of the agent now to be considered. We have shown that there is a great diminution in the vital changes during the summer season —a diminution so great in the extreme as one-half of the minimum or one-third of the maximum. Hence with a less abundant supply of that by which force is maintained and waste repaired, it must follow that exertion in any degree is then less tolerable than at a season of the year when these adverse conditions do not exist. The proof of this by actual demonstration is not, however, very easy, since by the proposition the amount of exertion made is within the limits of endurance of the individual; and, moreover, there is a power of adaptation existing within the system which most powerfully tends to prevent the evil influences of adverse agencies; but physiological reasoning is in itself conclusive upon this point. It is also manifest that with this relation existing, the influence of this agent will be the greatest at the end of summer, when the vital powers are and have long been very low.

321. *Relaxation of Tissue.*—We need not stay to prove that relaxation of muscular structure must powerfully tend to prevent rapidity and force of muscular contraction; for, putting aside any questions of electrical influence, the mere physical conditions will suffice to prove it. As the muscles are levers of various kinds, their power to act must vary with their length in relation to the fixed and moveable parts to which they are attached, and that length being fixed at a point the most conducive to their action, any increase of it must lessen their power of action, and thereby cause feebleness, and any decrease of it must tend to prevent rest, and thus bring on irregular action or spasm. As the muscular fibre is made up of a series of particles, placed side by side, the least variation in the tonicity of each minute body must produce a great effect upon the whole combination constituting the muscle, so that relaxation and feeble action may be most readily understood.

322. *Spring is the season of greatest muscular power and endurance, and then the winter.*

323. We have thus far referred to the period when the muscular power and endurance are lessened, or are at their minimum, and a few words only will suffice to describe them in their other conditions. No doubt in the winter these powers are much higher than in the summer, for then all the adverse conditions just discussed are much less powerful, and our personal experience demonstrates with how much greater ease and comfort we labour in the winter

than in the summer; but the spring time must, above all others, be that in which the muscular system is in its highest state of vigour. Then we have the greatest amount of vital changes proceeding within the system, and not so high a temperature as would prevent a full development of its power, whilst there is the most abundant supply of nutritive material to repair the waste thus occasioned. The summer with its relaxing heat, and the winter with contracting cold and impeding clothing, are far less suited to bodily exertion than the spring with its moderate temperature, bright sun, fresh breezes, and high vital actions. In this manner we arrive at the conclusion, that spring and autumn are the periods of maximum and minimum muscular power.

Sensibility.

324. *The sensibility of the system to temperature and tactile impressions is greatest in the spring and summer.*

325. It is admitted that those who inhabit warm climates are more sensitive than the inhabitants of extreme northern latitudes, and this is equally true of the mental and bodily organisation alike. In our own climate we find sensibility increased during the summer, as shown by the amount of irritation caused by a fly, or other insect, walking upon the skin, or by gnats or similar insects which wound the skin. The former is a fact familiar to every one; for whilst with

the rough and dry skin of winter a considerable amount of irritation may be tolerated, in summer the movement of a fly upon the back of the hand, or over the face, causes great uneasiness. So also in reference to the presence of flannel next the skin, and the use of irritating liniments, it is not generally possible to bear either so well in summer as in winter.

326. The effect of the sun's rays upon the skin is well known both in producing eruptive diseases and even inducing vesication, whilst equal heat from the fire in winter would have no such influence. This may be due both to the calorific and the chemical rays of the sun, but we do not now enter into that part of the question.

327. In the spring and early summer there is the largest distribution of blood to the skin, and in the former there is the highest degree of all vital action, and hence it is probable that then there is the greatest degree of normal sensibility; whilst, at the end of summer and in the beginning of autumn, the vital powers are then so much reduced that the increased sensibility is rather to be connected with the previous excessive action of the skin, and is more nearly allied to disease.

328. The ready susceptibility of those living in hot climates to the influence of morbid agencies, and more particularly at the end of summer, must be connected with the same fact, although it will also be associated with the further fact that at that period, chiefly or exclusively, are the morbid agencies present.

The difference in the readiness with which different persons become the victims of these agencies must chiefly be attributed to the variation in the degree of sensibility, as well as to the amount of vital action then existing. These two conditions seem to be indissolubly associated in the occurrence of such sporadic diseases as attack various nations at similar seasons of the year, whether it be cholera in this country or yellow fever in the Mexican Gulf.

Viability.

329. *The viability of those children is the greatest who are born in the winter and spring months, and the most suitable periods for marriage are the spring and summer months.*

330. Having ascertained the great variation which exists in the human system at different seasons of the year, and the especial liability to disease to which we shall presently refer, it seemed a necessary consequence that on due examination it would be found that changes of a corresponding kind would be found in reference to the period of procreation or of birth upon the human offspring. This is a matter of the utmost moment, both in a social and therapeutic point of view, for if such variations do exist, the knowledge of them ought to have an influence over the period of marriage, and it would help us to form a more just conclusion as to the liability of individuals to disease (including that condition which is known by the term

of constitutional tendency), and the probability of recovery from chronic diseases.

331. The influence of instinct in animals is such as to regulate the period both of conception and birth of their offspring; and it is worthy of note that whereas the sexual desires of animals are for the most part excited in the spring and early summer months, the birth of their offspring usually takes place in the cold season of the year. There are exceptions to this rule, as in the case of those which procreate several times in each year, and of those which live habitually in places in which they are not exposed to the full influence of the seasons, but it is commonly true of those which procreate once a year, and are exposed to the weather. It is also well known that a late calf for example, or one born at the end of summer, is less likely than another to become a well developed and healthy animal, and although this has been attributed to the chilling influence of the approaching winter, it is capable of another and probably truer explanation.

332. In searching for this knowledge in the human species we find that instincts are subordinated to other considerations, and hence we must look beyond their influence. If there be any variation in the viability of persons conceived or born in certain seasons of the year, or in other words in the varying states of vital power of their parents, we may seek for it either in the varying liability to disease of such persons, or in their very early decease. If it referred to the period

of conception, it would be open to inquiry how far the viability of the fœtus in utero was influenced thereby, and we might consequently seek to connect the cause of the death of the still-born child (when the death was not due to other manifest causes) with the period of conception; or if the child were born alive, it would be proper still to trace its liability to the attacks of disease, or its inherent power to resist morbid influences. If on the other hand it referred to the period of birth, then it would embrace only those born alive, and be traceable, as above mentioned, either in its early death or its liability to disease.

333. The variation which exists in the constitutional tendency to disease which we see in all men is fully admitted, and great importance is attached to it, both in reference to the probability of having certain diseases, and to the probable effects of curative agencies, and a large part of the treatment of children has for its aim to correct the evil tendencies which so often exist. This we have always connected with the parents, and so common is it, that the law is almost universal, "as is the vital power of the parents so may it be expected will be the vital powers of their offspring."

334. Again, an astounding loss of human life occurs in infancy, and in our search after its cause we fix upon three subjects, viz., the health of the parents, the hygienic condition of the child, and the great sensibility of the infant system, and they no doubt have the utmost value; still, a large proportion of infant

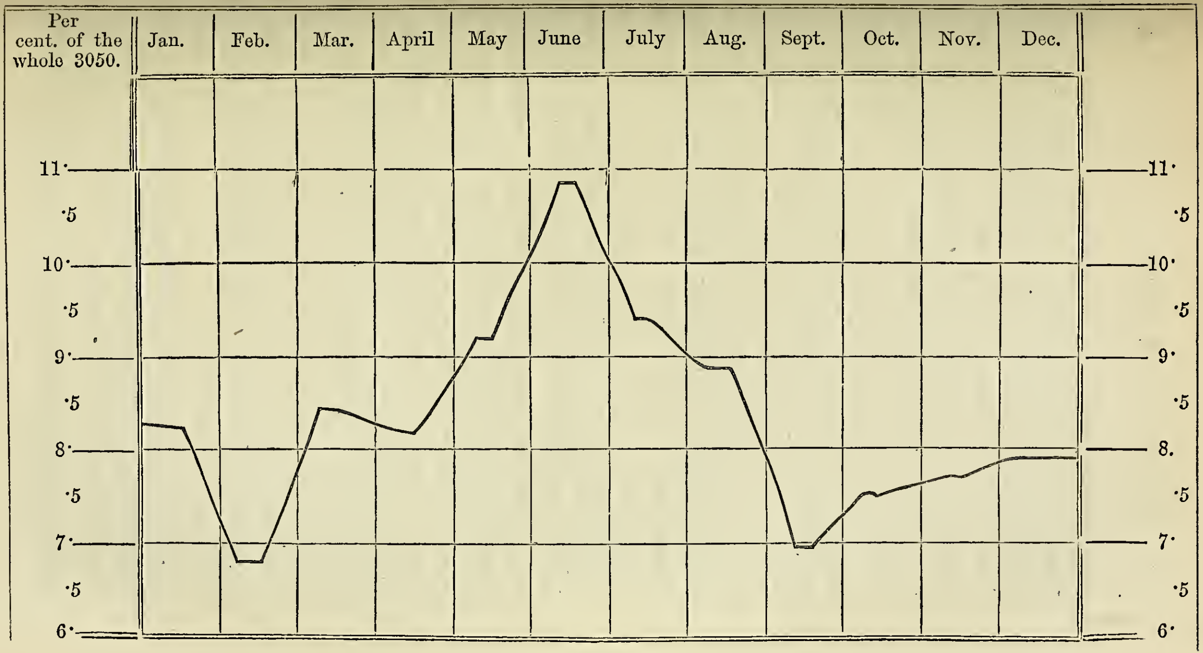
life seems to be lost without any adequate explanation offering itself. In searching into this subject, we first inquired if the deaths of infants dying under one year of age could be connected with either the period of their conception or that of their birth; and as it is customary in the certificates of death to state the age of the person dying, it followed that if we found the age registered in months, we could readily deduce the month of birth. In this way only could we obtain the information on a large scale in which the two facts of the precise period of birth and death might be connected, and as no published statement of this kind had been made, we applied to the Registrar-General and Dr. Farr for permission to make an analysis of certain mortuary returns for that purpose. With the courtesy which is always shown to an inquirer the requisite permission was granted, and on consideration we selected for the analysis the returns from a northern and chiefly country district, during a non-epidemic year, in the hope that we should thus exclude as far as possible merely local and adventitious causes of disease. The districts included the counties of Durham, Northumberland, Westmoreland, and Cumberland, with a population of about 1,000,000, and having scarcely any manufacturing towns. The population may therefore be presumed to be constitutionally as healthy as any in the kingdom, and the climate being cold, the influence of season would be less felt than in other localities, and hence in various ways the inquiry was subjected to

the least favourable conditions. The year selected for the period of death was 1857.

335. On careful analysis, and the exclusion of all doubtful cases, 3050 cases were found in which the children had died within one year of their birth, and in which the month of age at death was recorded. Of these 3050 children, it was found that the percentage of those born in the different months varied from less than 7 per cent. in February, and 7 per cent. in September, to nearly 11 per cent. in June, with a great progressive increase in May and June, and then a decrease in July, August, and September. During the months of October, November, and December the percentage was tolerably stationary, and somewhat under an uniform average of the whole year, viz., 8 per cent.; whilst in January it had risen to the uniform average, and in February it fell 1½ per cent., and rose an equal amount in March, in which month and in April the percentage was that found in January.

336. These facts are clearly represented to the eye in the following Diagram, No. 9, extracted from the "Medico-Chirurgical Transactions for 1859," which shows the percentage of births in each month of those who died under one year of age. A mere glance at this Diagram will suffice to prove that under the most unfavourable circumstances for the inquiry, it was shown that there was a marked variation in the viability of persons born in the various months of the year, and that whilst the greatest viability

Showing the Month of Birth of the Children Dying under One Year of Age. 1857.



occurred in those born in the winter months, the least was found in those born in the summer months. The months of May, June, July, and August were those in which the greatest percentage of those born in them died during the first year of their age. Hence it appears that this lessened viability is rather associated with the lessening powers of the human system at the season of birth than with the period of conception, and therefore is less associated with the system of the parent than that of the offspring; and it may be inferred that in man, in common with so many animals, his offspring born in the cold season has a higher probability of life than when born in the hot season.

337. It may be asked if this variation corresponds with a variation in the number of children born at these periods, and thus, by taking a percentage of the births and deaths of each season, the above-mentioned variations may be explained. The answer is, that it does not correspond with the number of children born in these seasons, whether legitimate or illegitimate; for although, with much variation, there is sometimes a very slight preponderance in the number of those born in the two middle quarters of the year, it does not in any degree correspond with the numbers now given.

338. It is, however, yet very desirable that this interesting fact should be tested under conditions more favourable to the existence of the diversity now sought, and that a distinction should be made between

the sexes, but it is manifestly impossible that any private individual could undertake so huge a mass of laborious investigation in the offices of the Registrar-General. We are happy to know that Dr. Farr is interested in the inquiry, and will, as opportunity may offer, direct the attention of his staff to its elucidation.

339. In reference to the other source of information, or the influence of the season over conception or birth upon the constitutional tendencies of our race, I trust that those physicians who see much of infantile disease will bear it in mind. As a physician attached to an hospital, at which we are extensively engaged in the treatment of constitutional conditions, we have entered upon this inquiry, but multifarious engagements have prevented any rapid progress being made. We have, however, obtained results which warrant us in inviting the attention of medical men to the influence which this cause of disease exerts even to and beyond adult life.

340. Without attaching too much importance to the information already obtained upon this subject, we think it is sufficient to warrant us in taking especial care of such children as are born in the hot season, especially in reference to the diseases to which infancy is prone, and the improvement which may be effected in the constitution of the child as it passes through childhood to adult life. The inquiry referred to did not embrace the cause of death, but it is highly probable that defective vitality was the leading

feature in such cases, for not only may that be inferred from the general condition of the human system then existing, but from the very significant fact that of the number, 868, who died in the third quarter of the year, 414, or very nearly one-half, were born in June, July, and August, and one-third were born in June and July only. It is true that in every quarter in which the deaths are recorded, a larger proportion was found to have been born in that quarter than in any other; but this excess bears no proportion to that which we have now recorded, and hence we must infer that a greater proportion of children born in the months of June, July, and August are likely to die very quickly after their birth than children born in other periods of the year. In the second quarter of the year, viz., April, May, and June, the proportion of those dying within seven days of birth to the whole number dying during that quarter under one year of age was one in less than every five, or 135 in 708, and of these 73 were males, and 62 females; whilst, in reference to the whole number of 708, the proportion of males to females was 38 to 32. We regret that a similar analysis was not made in the third quarter, but from the great mortality of those born in that quarter, it is very likely that at least an equal proportion died within seven days of birth. It would not be of practical value to deduce from such inquiries the most suitable period for marriage, since the period of that event is subjected to other circumstances, but we may

refer to popular opinion respecting it. Thus the author of "Spring" writes:

> "Then Nature all
> Wears to the lover's eye a look of love." . . . .
> "Flushed by the spirit of the genial year
> Now from the virgin's cheek a fresher bloom
> Shoots," . . . . . . "kind tumults seize
> Her veins, and all her yielding soul is love."

And Milton in a delightful sonnet sings:—

> "Hail, bounteous May, thou dost inspire
> Mirth, and youth, and warm desire."

There can be little doubt that the middle months of the year are to be preferred to the later ones, and however little the period of marriage may influence the season of birth of children in general, it will certainly control that of the first-born, and the heirs to the great names of our country.

Growth.

341. *The periods of maximum and minimum growth are spring and summer, on the one hand, and autumn and winter on the other.*

342. It is well known that animals grow more rapidly in spring than at any other season of the year, and this has been attributed to the abundance of herbage which they then find. A medical friend also assures us that he has ascertained by actual admeasurement that his children grow chiefly in the spring season. Being desirous to determine this interesting question, we made application to the

governing body of the Foundling Hospital for permission to determine the monthly rate of growth in height and weight, and the evolution of urea on one day monthly, in a large number of the children of both sexes, and regret to state that it was refused. In the course of one of the most extended series of inquiries which has ever been undertaken, this is nearly the only occasion on which an opportunity to add to useful knowledge has been denied us.

343. It is, however, in the highest degree probable that, as the vital actions attain their maximum in the spring, the greatest development of the system will then occur, and thus furnish another link to the chain which so closely binds the animal and the vegetable worlds. Hence if growth be in great part restricted to this one season of the year, those children who then suffer from disease, or who have not a good opportunity at that period of aiding the efforts of nature, must suffer irreparably, and the year be in a great measure lost to them. It is also the especial duty of those who have the charge of young persons to supply abundant food and enforce all hygienic conditions suited to promote their growth at this important period of the year.

344. The variation in the weight of the body is not an absolute test of the rate of growth, but as it is closely associated with it when it occurs over a lengthened period, we refer to the interesting experiments of Mr. Milner, who proved that the prisoners in Wakefield prison gained weight in the summer and

lost it in the winter. A large proportion of these persons were adults, but many of them were young men still in the period of growth.

Alimentation.

345. *There is less variation in the amount and kind of food taken by mankind than has been asserted.*

346. Various experiments have shown that a less quantity of food is consumed in summer than in winter, as for example those of Barral;[1] but it is doubtful if, in a state of health, this proceeds to any great extent. On inquiry at the Hospital for Consumption, &c., I find that even there the difference is very small and is chiefly in the article of bread, whilst the consumption of meat and other ordinary foods is not materially changed. I have recorded the quantity consumed by myself during the past year, but as there was so little summer weather, I am unable to show that any real variation exists; and, upon the whole, I am inclined to think that the difference is much less than has been asserted, and that, when it occurs, it is in a condition allied to disease.

347. In such inquiries as these we labour under the evident disadvantage of the appetite not being an accurate measure of the wants of the system; but, on the contrary, we allow license to our love of food, and commonly take more than is strictly necessary.

[1] Annal. de Chimie, 5e Série, vol. 25.

Hence, the appetite can only indicate the desire or love of food, and not the wants of the system, and it is rather by the amount of the excreted effête matter, as compared with the amount of food taken, that variations of the latter may be estimated.

348. So in reference to the actual variation in the dietary of persons living in different climates, there can be no doubt that the theory of nutrition based upon the animal temperature is not sustained by facts. In the hot climates of India and China a large quantity of starchy food is taken, conjoined with some portion of fat, the amount being determined less by the desire for it than by the lack of means to obtain it. The well-to-do Chinaman or East Indian eats abundance of fat and a large amount of starch. It is, however, highly probable that a less amount of animal flesh is eaten in hot climates than is customary in England, and certainly a less amount of exertion is made and less metamorphosis occurs.

349. In reference to the northern latitudes, as those of Sweden, there is no practical difference in the food eaten by the inhabitants and by ourselves, for there the working man lives chiefly upon herring and coarse rye bread. In yet higher latitudes, where the cereals do not grow, the inhabitants doubtless live almost exclusively upon animal food, and of this the fat of the cetaceæ and the seal, the flesh and blubber of the walrus, and the flesh of the bear, are the cheapest and the most readily accessible food. The flesh of the reindeer is too valuable to be generally consumed, and that

of bears and other terrestrial wild animals is too seldom found to render that kind of food common, except in certain parts of the Arctic regions; and hence that which we have been taught to regard as a necessity of their system is in fact a necessity of their means of living. Yet no doubt seems to exist that an abundance of flesh and fat is required in the highest latitudes, and the more so the greater amount of exposure and labour, but with the full rations allowed by our Navy, Sir James Ross found but little necessity for any addition under ordinary circumstances.

350. The Journal of Dr. Kane[1] contains many affecting incidents in reference to the want by his crew of suitable food when exposed to the rigours of the high latitudes; but it will be observed that their sufferings arose not from the want of animal food, considered abstractly, for they had at all times abundance of salted meat, but the want of *fresh* animal food. He writes rapturously of a dish of half a rat or a split puppy, or of portions of a fox's leg, and states that four ounces of meat which was served to his men was lamentably too little; but it is manifest that the ordinary rations of 1lb. of fresh meat per day would, with other articles of food, have abundantly supplied all their wants. He remarks that "this climate exacts heavy feeding, but it invites to muscular energy;" and he estimates the consumption of walrus meat by the Greenlanders at 6lbs. to 8lbs. per day when they

[1] "Arctic Exploration," 2 vols.

have it in abundance; but he also informs us that, in the depth of their dreary winter, when the store of walrus and bear flesh has failed, they are compelled to live on their dogs and to eat most sparingly. We should not be influenced in forming an opinion upon this subject, on the one hand, by the exaggerated appetites which savage men exhibit when, after long starving, they meet with an abundant supply of food; nor, on the other, when the proper supply is unattainable, but be guided by the conduct of civilised men who are regularly supplied with food. It is also to be remarked that vegetable food of any kind is almost entirely unattainable in these latitudes; but when bread was placed within the reach of the Greenlander he most greedily devoured it, and Dr. Kane affirmed that it was "hard to dispense with bread in eating cooked food," and also that bread was "precisely that of which our sick were most in need." In our own climate we find that from 5lbs. to 8lbs. of food, both solid and fluid, is consumed per man daily.

351. Milk is also abundantly taken in all climates where it can be obtained, as in the mountainous districts of Sweden and the Tyrol, in all positions in temperate climes, and in the deserts of Arabia, and other countries of the East. We have also had abundant testimony that the Hottentots of Africa, and the tribes amongst whom Dr. Livingstone travelled, are capable of eating an enormous amount of flesh when it is attainable by them, although they live in a hot

climate, and do not make any remarkable amount of exertion.

352. Upon the whole it is highly probable that the amount of food consumed by men in various parts of the world is not so different as we have been led to believe, and that the kind of food taken is less determined by the actual requirements of the system than by the opportunity of obtaining it, and therefore that the tolerable uniformity which exists in various seasons in our own climate is supported by this tolerable uniformity existing in the various climates of the world.

353. *The dangers from excess of refuse food are greater in the summer than in the winter.*

354. This follows from the facts, already recorded, that with a great diminution in the amount of vital change proceeding within the body, there is not a corresponding diminution in the amount of food taken, and also that, with the same amount of food eaten, there is less transformation and accumulation, and greater excretion of urea proceeding in the hot than in the cold season of the year. In both directions, therefore, there will be an increasing tendency as the summer advances to the accumulation of effête or imperfectly transformed material within the alimentary canal and in the blood, and unless this be renewed it must set up the diarrhœa which usually prevails at the period now indicated. This is seen in a striking manner at the boarding-houses of our southern watering-places, as at Ramsgate for example, where,

with abundance of good and savoury food, and pleasant society, there is a pressing temptation to take more food than is required by the system, and it is rare indeed that any new-comer is found who, in the hot season, does not have an attack of diarrhœa within a week or ten days of his arrival. This has been ascribed to the heat of the weather, and in proof it may be cited that, with the cold of the past summer, there has scarcely been a case of diarrhœa at Ramsgate or at other much frequented watering-places; but although the temperature is the predisposing cause, the efficient cause is the excess of food in relation to the chemical changes proceeding within the system with a high or low temperature. In almost all such cases, it must be admitted that whatever may be the temperature, diarrhœa would be almost unknown if the amount of food eaten were duly limited in quantity and quality; or, should any excess occur, if it were removed daily by suitable aperients. Diarrhœa from exhaustion, such as may be found at the end of summer, is very rare.

355. *Free dejection from the bowels is more necessary in summer than in winter.*

356. Nature indicates this by the tendency to constipation which all discover on the accession of cold weather, and the contrary in the summer season, and it results, no doubt, from the conditions discussed in the preceding paragraph. Hence, whilst as a fact aperient medicines are more commonly taken in winter than in summer, it would tend to the welfare

of the community if their frequency in the latter season were increased.

357. *Free emission of urea is the most necessary in spring and summer.*

358. The increasing formation of urea as the spring advances calls for a free elimination of it by the kidneys, and therefore for a free imbibition of fluid. It is highly probable that to the undue retention of urea is to be attributed various conditions, of which fever is an important sign, and in which the essential treatment is the free elimination of urea. It is evident from the previously recorded researches in reference to urea, that a large amount of it indicates excess of material and not excess of exertion; and since, as the spring advances into the summer, the latter is apt to be deficient and the former to increase, there will be an increasing probability of the retention of urea.

359. *Spring is the season the most fraught with danger from excess of transformation of food.*

360. This results from the activity of the vital processes at that period, conjoined with the natural disposition then and at all times existing to take excess of food, and unless the waste of system be increased in the like proportion, it is manifest that superabundance of nutriment in the blood must result. In the early part of the spring, when the temperature is yet low, there is not a natural tendency to diarrhœa whereby this excess may be in part removed, and hence that is the period of greatest liability to inflammation; but in the later period the increasing tem-

perature offers relief in that direction, and the danger is averted.

361. We found, in the course of our experiments, that with headache and stomach derangement there was commonly a temporary diminution in the amount of urea evolved, although there was no material diminution in the food taken, and relief was accompanied by an increased elimination of urea. The rate of elimination of urea was commonly high immediately before the headache, but it was not clearly shown that the condition of the ureal elimination was the cause of the headache.

362. *It is probable that nitrogenous foods are more necessary in the hot season than we at present admit.*

363. We have shown that in the winter there is a large amount of vital action, and, at rest, cold is the most powerful respiratory excitant which we possess; but in summer this excitant is removed, and the whole attendant circumstances tend to lessen vital action. Hence, those foods which promote the transformation of material seem to be especially called for in circumstances in which there must be exertion made with a high temperature: but as we purpose to discuss this subject elsewhere, we will only occupy a few lines in the present place. We have recently shown that all nitrogenous foods are respiratory excitants, and as such must tend to the more rapid conversion of the hydro-carbons. These are especially the common beverages, tea and coffee, and also animal flesh. Our own experience, as well as that of the Chinese, abun-

dantly confirms the statement as to the beneficial influence of tea and coffee in the hot season; but we do not attach the same value to the use of flesh; and, indeed, there is this manifest distinction, that whereas tea and coffee offer but little to be transformed, and are themselves almost exclusively used in promoting the transformation of other food, flesh by its fat, even when it appears to be lean, offers a large amount of material to be transformed, as well as the nitrogenous transforming element. Hence it is manifest, that if flesh be eaten freely in summer, the use of the cereals should be lessened; whilst the usual quantity of the latter may be taken if tea or coffee only be employed. The question is, however, whether a dietary for hot weather in our climate would not be far more healthful if composed of a fair amount of animal food and a small amount of starch, than one with a full amount of starch and fat and a small amount of flesh, and we are prepared to affirm that it would be better, and would do much to counteract the evils of lessening assimilation which multiply as the summer advances. A diet in which lean animal food figures moderately, and starchy food is very sparingly found, should be the dietary for hot weather. Tea and coffee are beneficial in either kind of dietary in proportion to the excess of food and the lessened powers of transformation; whilst the use of a small quantity (a wineglassful at a time) of old-fashioned ale is particularly useful with the starchy dietary and *excessive* action of the skin, from its gluten and sugar which tend to

promote the transformation of starch, and its alcohol which tends to lessen the action of the skin. It must, however, be very rarely indeed that, under *ordinary* circumstances and in *health,* the habitual use of alcohols of any kind can be *required* by the system.

364. *The use of diluents is nearly equally necessary at all seasons of the year, but for very different purposes.*

365. The first part of this assertion may appear to be incorrect, since it is probable that men do commonly drink more fluid in summer than in winter; but that is in great part due to the habit of indulging in that which, by relieving thirst, is pleasant to the system, and might be increased almost indefinitely by repeated indulgence. We well recollect in our first walk through Switzerland that we stopped at every rivulet to drink the cool and grateful water, just as in the rolling uplands of Texas we dismounted at every stream, and lay for some minutes in water comparatively cool at 70°; but in the former case our guides assured us that it was not necessary, and that the more we drank the more we should desire to drink, whilst in the latter we were threatened with attacks of fever from so often interfering with the natural action of the skin. Hence, in reference to fluids as well as to solid food, the appetite is not a sufficient measure of the true wants of the system.

366. In winter diluents are especially needed to enable the urea to be freely evolved, as we have already indicated, and also to afford a considerable

quantity of fluid to the alimentary canal with a view to facilitate the evacuation of refuse material. When a fluid of low specific gravity is employed, it will be taken up by the veins, carried into the circulation, and ultimately issued by the kidneys; but should it be sufficiently in excess of this power of absorption it will remain in the alimentary tract. Hence in both degrees diluents are useful, the first by acting through the kidneys, and the second by the bowels.

367. In the summer season diluents are chiefly required to supply a sufficient amount of fluid for the purposes of the perspiration, since it rarely happens with a well-regulated dietary that there is any lack for the two purposes just referred to. To serve the purpose of the perspiration, it must be of less specific gravity than the serum of the blood, for otherwise it would pass off by the bowel and induce diarrhœa, and when the perspiration is very active it can scarcely be supplied too abundantly. Hence the free use of some kind of diluent is essential in hot climates, and whether it should be simply water, or tea, or coffee should be determined by the required degree of activity of the skin—the two former tending to increase and the latter to decrease it. Alcohols cannot be justified under ordinary circumstances, and it is only in the cases of excess of skin-action with deficient force of the heart (conditions found only in various forms of debility or after unusual exertion,) that they can be given with impunity; for although they may exert a beneficial influence in sustaining

the action of the heart, they are likely to be injurious in lessening the activity of the skin.

Amount of Blood.

368. *The amount of blood is probably the greatest in the spring and the least at the end of summer.*

369. We have already shown (141 *et seq.*) that the quantity of blood varies at different hours of the day according to the relative amounts of the ingesta and egesta. There is equal reason to believe that it varies also with the season, and is the greatest at that period in which the barometric pressure is the least, when the temperature is increasing, and when the amount of fluid nutriment is the greatest.

370. In the spring these conditions exist more commonly than at other periods, and as we have shown in how much greater a degree all vital changes proceed at that than at other periods of the year, it is almost certain that in spring-time there is the greatest, as at the end of summer there is the least, quantity of blood. In the spring-time, moreover, there is a genial temperature, so that the blood is distributed freely to the skin, whilst at the same time it is abundant at the centres for the purposes of vital action—a circumstance which must be associated with the greatest amount of blood. The distribution of blood to the surface is essentially connected with the necessity for a free disengagement of heat, either as resulting from mere external temperature or as due to the influence

of exercise, and in both directions we see a reason for this fullness of the blood-vessels in the spring season.

371. In the winter season there is a medium amount of blood, and it is chiefly found at the centres.

The Turkish Bath.

372. *The Turkish bath may be beneficial in spring and summer, and at the change of the seasons, but can only be useful in conditions of the system in which there has been an undue retention of fluids, or in which the skin is deficient in activity.*

373. We have determined the influence of sudden increase of temperature in increasing the respiratory and circulatory functions on several occasions, but not to the degree which is employed in the Turkish bath. The following is the result of an inquiry made on September 12, 1857. After having sat in a dark and damp room 21 minutes, with a temperature of $61\frac{1}{2}°$ wet and 63° dry, we breathed 425 cubic inches of air per minute in 13·8 inspirations, but on exposure to the sun's heat and light there was an increase of 13·6 and 24·2 per cent of air, and of 3 and 4·3 per cent. in the rate of respiration. On being exposed to a dry heat of 109° dry and 98° wet during 40 minutes, the increase in the quantity of air inspired amounted to 42·3, and of the rate of respiration to 9 per cent. in 40 minutes. The quantity of air inspired declined 30 per cent. when, after steam had been mixed with

the air, the temperature had fallen to 96°, and 24·2 per cent. after having sat in an unheated room with the temperature of 68° dry. Thus there was a considerable and progressive increase in the quantity of air inspired and in the rate of respiration as the temperature increased, and there was a decrease as the temperature fell, but the effect of the previous elevation of temperature remained, in some degree, long after the temperature had considerably fallen. The effect of saturated air was less than that of dry air. The rate of pulsation increased, with increasing temperature, from 80 to 96, and fell, with decreasing heat, to 76 per minute.

374. There can be no doubt that the direct effect of an air-bath at high temperature must be to increase the respiratory function, to quicken the circulation, to excite the action of the skin, and to eliminate certain blood products, as urea, which ordinarily find another outlet—that is to say, to increase transformation and the waste of fluid, and to cause a revulsion from other organs. The indirect action is to disturb the balance of the functions, to lessen the excretion of urinary products by the kidneys, and to constipate the bowels. The general expression of its remedial efficacy is the removal of excess, and if there should be no excess it will then increase waste and produce exhaustion. Its action upon the respiratory function may be most useful as the summer advances, but it will then add an additional cause of acceleration of the pulse which may be more or less injurious. In reference to the

retention of fluid, we may remark that variations of great extent in the amount of fluid egested are common in health; and that retention is found on the first day of a thaw, when the barometer first falls, after certain kinds of food, and with sudden heat, so that an increase in the weight of the body, to the extent of 3 ℔., may occur in a single day. In such a state there is a sense of fulness and heaviness, or lassitude, and then the Turkish bath would be very beneficial; but ordinarily Nature brings relief, and the urine, which had fallen to 40 ounces, rises again on the following, or on the third day, to 60 or 70 ounces during the day. With diminished urine and retained fluid the bath is proper; but it may even then be questioned as to how far the power of revulsion which it exerts, by which urea is abundantly thrown out by the skin instead of by the kidneys, is a natural act, or, on the contrary, one tending to derange the harmonious working of the system. When, however, there is no retention of fluid in the body, when the urine is emitted freely, and when the body is losing weight simply from that cause, the bath must be prejudicial; and by unduly reducing the volume of the circulating fluid, will lessen all the vital powers, and also induce the usual train of evils which follow continued constipation.

375. Regarded abstractedly, the use of the Turkish bath is a most unphilosophical procedure in a temperate or cold climate; for whilst the chief object of every man is by clothing and shelter to avoid extremes of temperature, and to keep the body in an uniform

condition, this modern luxury exposes the body to the greatest extremes with which we are acquainted. It is difficult to imagine any contrivance more likely than this to be injurious when employed in an indiscriminate manner and in health, whilst it is probably a remedial agent of great power in the favourable conditions to which we have just referred.

376. Its common victims will be the feeble with deficient powers of assimilation, and the plethoric with a tendency to extravasation of blood, and those who have passed middle-life will be more liable to injury than the young. Its devotees should be those up to middle-life, who eat more food than they can transform or than they need, and particularly food in which alcohols and animal matters form a large part, and cause the fluids to be retained in the body and the skin to become dry. After an excessive dinner, or an occasional debauch with excess of wines or spirits, the use of the bath on the following morning would give great relief, and particularly if this condition should occur in the hot season. In the cold season the skin is naturally less active and sensitive, and upon these conditions depends our toleration of cold; but the frequent use of the bath at that season would remove these natural safeguards.

Liability to Disease.

377. The existence of seasonal disease is well established, for from the era of Hippocrates to our day

the experience of mankind has borne testimony to the variations in the prevalence of disease at various seasons of the year, and to the fact that the same kind of disease assumes a different aspect at various seasons; or, to speak more generally, in various years. We need only refer to the occurrence of the plague in London in 1593, 1603, 1625, 1636, and 1665,* all of which received their vast development in the hot season, and to the general manifestation of cholera in our day at the same periods. The occurrence of yellow fever at the end of summer in southern climes, the prevalence of special eruptive maladies at different seasons, and the occurrence of inflammatory diseases in the cold season, are familiar illustrations of universal belief upon this subject; but as we shall hereafter give details upon this question, we shall not now discuss it further.

378. *The foundation of seasonal disease is the varying degree of vital action proceeding within the body at the different seasons of the year.*

379. We must admit that disease is in its principal forms an exaggeration of a natural tendency then existing in the human body—a tendency which only becomes disease when carried beyond a certain limit. Thus we find that a person of feeble habit is especially liable to disease in which exhaustion is a prominent feature, and one of plethoric habit is unusually exposed to congestive and inflammatory diseases.

* "Report on Cholera" (Dr. Farr), p. clxxiii.

380. We have already shown that the human system varies in its amount of vital action in a very definitive manner, the maximum being in the spring, the decline and the minimum in the summer, the minimum and the increase in the autumn, and a stationary elevation in the winter. Just in the like order is it exposed to an exaggeration of these tendencies. Thus as a rule the diseases of the end of summer are those of exhaustion, whilst those of winter and spring are known as inflammations, and those of autumn and the end of spring are marked by such conditions as result from rapid variation in the animal economy in its relation to the influence of external agents. There is also a variation in the type of disease according to the advancing tendency of the system, so that in the later part of spring, when there is the commencement of a downward tendency of the vital actions, the progressive attacks of the diseases will progressively show an asthenic type, until they at length terminate in the diseases of exhaustion infesting the summer season; whilst, on the other hand, diseases occurring at the end of summer and the early autumn progressively change their aspect from the asthenic form until they merge into the sthenic conditions of winter.

381. Hence there are both settled sthenic and asthenic conditions, and conditions varying in a definite direction between them, and as they are due to the amount of vital action existing (which results from the influence of the agencies which constitute

the season), so will the sthenic or asthenic character be manifested at their respective seasons. With this key, therefore, we may not only foretell the character of disease at a given period of the year, but may also be acquainted with the variations in the type of the same disease, as manifestations of it may from time to time occur with the progression of the seasons. Thus, for example, an attack of scarlatina occurring at the end of a hot summer and with a warm and moist autumn must manifest a distinctly adynamic type, whilst if it occur after the cold weather has set in, or during a cold summer, it will be more and more inflammatory until the system is no longer very liable to that form of disease.

382. *There are diseases which result from an arrest or lessening of the natural tendencies of the system.*

383. Such is the character of disease which is induced by an excess of seasonal influences or in a system unusually sensitive to the ordinary degrees of seasonal influence, viz., one of exaggeration of the natural tendencies of the system; but there are other diseases arising from a contrary condition. Thus if when the temperature is increasing, and the skin is required to be unusually active, so as to produce great dispersion of heat, some condition occurs which leads to the arrest of, or a serious diminution in, the action of the skin, the natural tendency of the system is thwarted, and the only condition compatible with health being for the time set aside, a state of disease immediately ensues. This is familiarly illustrated by

a cold, the ordinary effect of undue exposure of a part of the body to a lower temperature, and also by the indulgence in such articles of food as tend to lessen the action of the skin. Or again, if during the winter, when the action of the skin and the sensibility of the surface should be much reduced so as to prevent an undue waste of heat, and to pass unheeded the influence of cold, a condition be imparted which tends to maintain the skin in the normal activity of summer—as for example the occupation of highly heated apartments, or the constant use of the Turkish bath—the body will be liable to the effects of too great dispersion of heat, and will certainly be more sensitive to the influence of external cold. Or finally, if with the necessity for high vital action in the winter and spring there should be deficient nutriment supplied, there will be an arrest of that condition which is natural to the body at that period of the year.

384. All this latter class of causes may be regarded as adventitious or accidental, and they act by arresting the natural order of the phenomena within the system; whilst the former are, so to speak, natural—for the most part flowing from natural causes—and act by adding force to the natural order of phenomena. Both are connected with season, but the latter alone can be truly regarded as seasonal, and subject to the law of cyclical change which we are now discussing.

385. *The constitutional peculiarities of individuals modify the effects of season.*

386. The relation of these internal changes has

already been demonstrated, but it may be well to show yet more clearly that there is a constant antagonism proceeding between those external influences and the vital actions of the system; and although the influence of the external agents will in the end draw the vital changes of the body in their train, there is not an uniform readiness to submit to their controlling power. This is commonly referred to the constitution of the individual, so that it is said that such an one "suffers much from hot weather," or he "bears hot or cold weather well," according to the peculiar tendencies of his system to aid or resist the influence of external agencies. The former illustration has been abundantly exemplified in two investigations which have been already referred to. In that conducted at the Brompton Hospital on 15 cases of phthisis, during the increasing temperature of the month of June (36), there was found to be great variation in the effects of the season in the different cases, and it was ascertained beyond a doubt that those who knew from experience that they bore heat badly had an excess of all the seasonal effects. So, in like manner, when determining the amount of carbonic acid evolved daily during the year (p. 270), Mr. Moul, who suffers much from heat, showed a much greater diminution in the amount of carbonic acid evolved under the influence of temperature than we evinced who bear heat well—his diminution being, as already stated, 27 per cent. at the middle of June, whilst ours was but little more than that amount at the end of August.

387. In this, no doubt, lies the explanation of the selection of a few victims when many persons are exposed to the same morbid conditions, for it is well known that, although there may be an epidemic of influenza or an outbreak of cholera which may extend over a great city, only a small proportion of the population thus exposed will be seized by it. It has always been difficult to explain this fact, and hence many theories have arisen referring to the accumulation and the transmission of the morbid influence, each of which may have some weight, but no one has been shown to exert so general a power as to be regarded as an adequate cause of this diversity. Now, however, it having been proved that morbid influences arise under certain external conditions which, whilst they lead to variations in the vital powers of the system, have greater influence upon certain individuals than upon others, we have a ready and general explanation of the selection of such persons as the earliest victims. But, with this truth admitted, we may still need increased information as to the origin and transmission of the morbid influence, as well as to the mode by which those external agencies act which both engender these morbid agents and prepare the system for the reception of their influence.

388. *The dangers to be apprehended in the progress of disease vary with the season.*

389. In the maximum and minimum conditions of the system we find that causes have been long acting, and have gained power by continuance, and hence *the*

dangers will increase as the season progresses. This we shall show to be the case in a remarkable degree in the summer season, as manifested by the progress of cholera, and in the winter season by the progress of bronchitis.

390. In the season of change the danger lies in the difficulty of adapting the body with its numerous functions to a new order of external phenomena, and hence *the danger will be the greatest at the commencement of the period of change,* and this may be well illustrated by the early severity and special cause of death from eruptive diseases at the two periods of change.

391. *The frequency of certain diseases has a relation to the season and to the nature of the disease.*

392. We have affirmed that the diseases of the hot weather show an adynamic, and those of the cold weather a dynamic type, whilst the characteristic of the spring and autumn months is that of change; and we now purpose to show that such is the actual nature of the diseases which prevail at those periods.

393. For this purpose we have analysed the London returns of the Registrar-General for the five non-epidemic years of 1850 to 1854, both inclusive, and have ascertained the amount of mortality which occurred from each disease in each quarter of the several years. When these results are compared with the mortality which would have occurred had the deaths been uniformly distributed over the year, we at once perceive the periods of excess or defect, and it is upon

that principle that the following table (No. 27), has been compiled:

TABLE No. 27,

Showing the Excess or Defect in the Prevalence of Certain Diseases at each Season of the Year, from the Amount which would have occurred had the Mortality been equally distributed through the Year.

Disease.	Vital Changes. 1st Quar. Maximum.	2nd Quar. Maximum and Decreasing.	3rd Quar. Decreasing and Minimum.	4th Quar. Minimum and Increasing.
Diarrhœa . .	— 15·2	— 14·5	+ 36·4	— 6·9
Enteritis . . .	— 1·7	+ 2·9	+ 4·	+ ·2
Gastritis . .	— 2·4	+ 1·4	+ 4·4	— 4·6
Nephritis . .	+ 2·3	— ·5	+ 3·4	— ·8
Peritonitis . .	+ ·7	+ 4·6	— 4·1	— 1·4
Pleuritis . . .	+ 5	+ 5·0	— 6·2	— ·3
Bronchitis . .	+ 12·9	— 1·9	— 14·	+ 2·8
Pneumonia . .	+ 4·8	+ 1·1	— 10·7	+ 6·7
Pericarditis . .	+ 4·5	+ ·3	— 6·4	+ 1·5
Cephalitis . . .	+ 1·6	+ ·5		— 2·3
Convulsion . .	+ 2·7	— ·6	— 2·1	— ·2
Apoplexy . .	+ 2·6	— 1·7	— 2·1	+ 1·2
Epilepsy . .	+ 2·4	— 3·7	— 2·3	+ 3·
Smallpox . . .	+ 1·	+ 1·4	— 4·	+ 1·3
Measles . . .	— 1·1	+ 6·4	— 5·8	— ·1
Scarlatina . . .	— 8·3	— 4·6	— ·2	+ 12·5
Typhus . . .	— 2·1	— 2·	+ ·5	+ 4·2

394. It is manifest that there are inconveniences in the construction of this table, for as we have shown that certain months exhibit changes of far greater

magnitude than others which are comprehended in the same quarter, the full effect cannot be shown when all are added together. This is particularly the case in the second quarter, for whilst April and May are maximum months, June is a month of marked decline. Such diseases, therefore, as depend upon a diminution in the vital powers will scarcely exhibit this characteristic when compared with the conditions of the previous maximum periods. Hence it would have been better for our purpose if the mortality from each disease could have been recorded in each month separately, but the publications of the Registrar-General do not give the required data.

395. Again, the mortality is not sufficient evidence of the prevalence of a disease, for whilst it embraces the question of frequency, as well as that of intensity, the former is necessarily subordinate to the latter, but here also published data fail us, and we are compelled to be content with a knowledge of the mortality alone.

396. All these circumstances militate against the full development of the results which we seek; and whilst the latter are very decided in the foregoing table, it may be inferred that their value is greater than the treble power.

397. *Diseases of the alimentary canal have their maximum intensity and frequency at the period of minimum vitality.*

398. Diarrhœa is the most marked illustration of this fact, for whilst there is a defect in each of the

three other quarters, there is an excess of no less than 36 per cent. in the quarter of minimum vitality, and the extremes are so great as a defect of 15 per cent. in the maximum, and an excess of 36 per cent. in the minimum quarter. These numbers are so decided that for all practical purposes diarrhœa may be regarded as a disease solely of the minimum period of vitality; and when it occurs at other periods, we may readily believe that it is due to fortuitous circumstances, or occurs in a state of system which in an unusual degree evinces the characters of the human system in general at the minimum period of vitality. Cholera, in its various outbreaks in England, has followed a similar progression, and has proved itself to be essentially a disease of the minimum period of vitality.

399. The following Table, No. 28, shows this fact

TABLE No. 28,

SHOWING THE MONTHLY PROPORTION PER CENT. OF ALL THE DEATHS FROM CHOLERA IN 1832 AND 1849.

	1832. Per cent.	1849. Per cent.
May . .	2·41	·60
June . .	4·40	3·76
July . .	13·57	13·91
August . .	28·69	29·17
September .	17·71	37·46
October . .	13·19	8·55
November .	2·59	1·55

in a striking manner in the two outbreaks of 1832 and 1849 by the percentage of deaths which occurred in England in the months of May, June, July, August, September, October and November.

400. There was thus a progressive increase in the mortality from cholera through June and July to the maximum mortality in August in 1832, and through June, July and August to the maximum in September 1849, and thenceforward in both years there was a rapid decline. These facts show a great preponderance of mortality in the two months when the vital actions were at the minimum.

401. It is interesting to notice that the month of maximum mortality from cholera was earlier in Paris than in this country, viz., in June in 1849, and even in April in 1832, but there is so great a want of uniformity in the progression of the monthly returns from that city that we are tempted to doubt if the records have been well kept, or if the features of this disease were the same in Paris as in London. It is, however, highly probable that a disease which is so closely connected with the degree of vital power of the body will exhibit different manifestations in different countries and climates, for the human constitution certainly differs in its power in various parts of the world, and hence will vary in its capability to resist morbid agencies.

402. Enteritis and gastritis produced their maximum of mortality in the second and third, or decreasing and minimum quarters, whilst there was a defect

on the average in both diseases in the maximum period of vitality, and in gastritis the defect was continued even into the increasing period.

403. *The greatest mortality from the plague in England occurred at the minimum period of vitality.*

404. The various attacks of the disease known as the plague, which occurred in London in the 16th and 17th centuries, exhibited the same features as the cholera of our day in reference to the question now under discussion, and show a remarkable similarity in the essential nature of the two diseases, as the following extracts from a table copied into the same report from Mr. Marshall's work on the mortality of the metropolis very clearly show (Table No. 29).

405. In each of these outbreaks it will be seen that the great development of the attack occurred in July, and reached its maximum point in the minimum months of vitality, viz., in August and September, whilst in November the disease had nearly disappeared.

406. *The greatest mortality in chest diseases is found in the periods of increasing and maximum vital action, and the least mortality at those of minimum vital action.*

407. This is shown by the deaths from bronchitis, pneumonia, and pleuritis, and especially in bronchitis, in which the extreme difference was so great as a defect of nearly 11 per cent. in the minimum, and an excess of nearly 13 per cent. in the maximum period. There is no exception to be found in the returns in these two directions; but in reference to the second

TABLE No. 29,

Showing the Weekly Number of Deaths from the Plague in London, in the various epidemics, contrasted with the usual mortality in other Years.

Week.	Average of 7 Years, 1640–46.	Periods of Plague.			
		1593.	1603.	1625.	1665.
27	211	850	267	640	684
28	214	1440	445	942	1006
29	210	1510	612	1222	1268
30	235	1491	1186	1741	1761
31	259	1507	1728	2850	2785
32	278	1503	2256	3583	3014
33	282	1550	2077	4517	4030
34	333	1532	3054	4855	5319
35	353	1508	2853	5205	5568
36	379	1490	3385	4841	7496
37	395	1210	3078	3897	8252
38	372	621	3129	3157	7690
39	373	629	2456	2148	8297
40	385	450	1961	1994	6460
41	364	...	1831	1236	5720
42	365	...	1312	838	5068
43	338	...	766	815	3219
44	320	...	425	661	1806
45	301	...	...	375	1388
46	284	...	...	...	1789
47	247	...	...	...	1359
48	247	...	...	...	405

quarter of the year, in which there is a mixture of influences, we find that whilst the deaths from bronchitis were then in defect, those from pneumonia and pleuritis were still in excess—a fact doubtless owing to the admixture of the returns in April and May with those in June.

408. Pericarditis followed precisely the order of pneumonia, and had its maximum at the period of maximum vital action and *vice versâ,* and the defect in the summer season was so much as $6\frac{1}{2}$ per cent.

409. *Brain diseases prevail in the cold season.*

410. Apoplexy and epilepsy exhibited an excess of deaths in the increasing and maximum periods of vitality, and convulsions were in excess at the latter period only, whilst in all these diseases there was the least mortality at the periods of decreasing and minimum action.

411. *Eruptive diseases for the most part prevail at the seasons of change.*

412. This is a part of the subject worthy of the most profound study, and one which is necessarily most complicated in its details, for at the same period we find the confluence of two sets of causes which are antagonistic to each other, and which have to be reconciled by the system exposed to their influence. In the end of the struggle the conditions of the advancing season gain the mastery, but in the earlier period we are subjected to the evils of the soft, sensitive, perspiring skin of the end of summer being exposed to the rude equinoctial blasts, the enfeebled

powers of assimilation struggling more or less feebly to supply the increased vital transformation which the cooler weather demands, and the active pulsation of the heart opposed by the lessened action of the skin, which, being accompanied by contraction of the capillaries, offers an unusual obstacle to the current of the blood at the surface, and causes it to accumulate in the internal parts. These and other antagonistic influences are doubtless the cause of much autumnal disease, just as in the contrary conditions of spring we find spring diseases, all of which are due to the antagonistic influence of a new order of external phenomena upon a system which may not be able to adapt itself quickly enough to those novel influences.

413. We do not purpose to enter at length into this interesting question, but will only point out one or two of the most remarkable agreements or diversities to be met with in these seasonal diseases.

414. Scarlatina and typhus show a remarkable correspondence under this head, since both were most fatal in the increasing periods of vitality, and the least so in the next quarter when the vital powers were the highest. Measles and scarlatina offer as remarkable a contrast, for the greatest mortality from the former occurred at the period of decreasing, and the latter at that of increasing vital changes. Small-pox offered less diversity than might perhaps have been expected (the cases of death are happily now few), but the least mortality was found with low vital action.

415. In seeking to connect epidemics and eruptive diseases with certain states of vitality of the system, we must especially bear in mind the caution already given, that the nature of the season will exert a great effect not only upon the type of that attack of the disease, but upon the month in which the maximum or minimum mortality will occur. Hence we are prepared to find that there was a retrocession in time in the epidemic of scarlatina in 1844 and 1848, and it is probable that measles will scarcely be more fatal in the second than in any other quarter if the spring and summer be cold. But these do not materially affect the general rule, that measles will be more fatal at the beginning of summer and scarlatina at the beginning of winter.

416. *The type of a disease has also reference to the conditions of the system which preceded its occurrence.*

417. This consideration is especially applicable to autumnal diseases, which occur with an increasing, but immediately follow the period of minimum, state of the vital powers. It has been often stated in the preceding pages that there is a progressive decline of the vital actions during two or three months at the middle and end of summer; but the minimum period is not an extended one—not so extended as the maximum period in the spring—and hence the upward tendency, which occurs at the middle of September, induces a somewhat sudden change in the vital actions, and during this period of change eruptive diseases, as

scarlatina, are very apt to occur. It is therefore easy to understand that the type of a disease, commencing immediately on the occurrence of this change, will have more reference to the period of low vital power, which has just passed over, than that of the same disease appearing when the upward tendency has become well developed. The former would exhibit adynamic and the latter dynamic conditions.

418. Hence, not only must we look forward to the advancing season in order to judge of the type of any epidemic which may be existing, but we must have regard to the season which is just passing—or has very recently passed—in order to estimate rightly the type of the existing attack; and as this is particularly applicable to the seasons which we have called seasons of change, we may very well take scarlatina in the autumn and measles in the spring as illustrative of these two conditions. The early cases of scarlatina will be marked especially by exhaustion and the latter by inflammatory complications, whilst the early cases of measles will be marked by inflammation and the latter by prostration. The Table under consideration (No. 27) shows that there is a decided difference in those two diseases as to the condition of system in which they commonly arise; but, as has already been intimated, should the conditions be transposed to other months, these diseases may assume each other's special characters.

419. An excess of seasonal conditions, whatever they may be, will induce an excess of seasonal disease;

whilst any marked defect of the former may cause the importation of diseases which are commonly restricted to other seasons.

The Cure of Disease.

420. This is, no doubt, one of the most interesting parts of our subject, and it is one which seems to have derived light from the discovery of the cyclical changes proceeding in the body from season to season. It is one, moreover, which does not demand any lengthened discussion, since, if the facts already given be correct, the issue seems inevitably to follow.

421. We have shown that each season as it occurs brings its own special causes of disease, both in relation to the varying states of vitality of the system and the difficulty of adapting any existing state of the system to a new order of external phenomena. These disturbing causes act by slow degrees, so that their influence may be imperceptible in any very short period of time, or, (as is more commonly found in our climate where there is a want of uniformity in the progress of seasonal changes,) they act more violently and cause sudden disturbances of the system which attract attention and then pass away; but when regarded in the longer periods, which we denominate the seasons, their influence is readily perceptible. It has also been shown that the diseases of each season vary in their character, and are not the same throughout the year; and hence it follows that the diseases of one season pass away as those of another season arise.

We have also shown that with regard to many, and those the most fatal diseases, the origin, increase, decrease, and disappearance of the epidemic may be traced, and all these follow in a defined order.

422. *The rotation of the seasons is a chief element in the* vis medicatrix naturæ.

423. From the foregoing facts it follows, that just as the seasons produce disease, so the change of season cures disease; and, in truth, that this is the explanation—at least in great part—of the mystery, the "vis medicatrix naturæ." This is Nature's method of treating and curing diseases when we refer to the progress of an epidemic, or to chronic and constitutional conditions in individuals.

424. *The change of seasons is the safeguard of the human race.*

425. On reflecting for a moment upon this subject, we shall see that there is probability upon the face of this statement, and further reflection will show that it is supported by abundant evidence. If there be a condition of system in which a disease exclusively or chiefly appears, is it not rational to presume that as that condition changes into its opposite, it will not only cease to produce but to support it, and, in fact, that the system will thenceforward, after due time, fall into its ordinary and healthful course? No one will deny the first part of the assertion, but it may be questioned as to how far the change of season will remove a morbid state which has been set up by the previously existing cause. The answer to such a

question is, that not only is the condition which caused the disease removed, but the new condition is favourable to the very state which the individual now seeks. Thus, for example, we find an individual upon whom the heat and other phenomena of summer have had great influence is suffering from general languor, muscular relaxation, defective appetite and power of assimilation, perspiring skin, and languid circulation; all leading to sanguineous congestion, and to dropsical effusion in the cellular tissue of the feet. Such a person on the advent of the cold weather should, according to the above statements, find these various conditions in process of removal, and his health more or less completely restored. How is this to be effected? Simply by the new conditions in which he, in common with all men, is then placed; for we have shown that the cold season will increase vital action, and this will repair his appetite and power of assimilation and of absorption; will lessen the action of the skin, which, by offering resistance to the current of blood, will increase the *force* of the circulation, and thereby remove the tendency to congestion; and will give tone to his tissue, which will increase muscular power, and aid in sustaining the return current of blood. All these changes occur to every man in health, and, therefore, why not to the sufferer in question, at least so far as relates to conditions which are not due to altered structure of organs? We contend that, under any circumstances, the new season will have this tendency, and will there-

fore improve every hopeful case, and will cure such as are capable of cure.

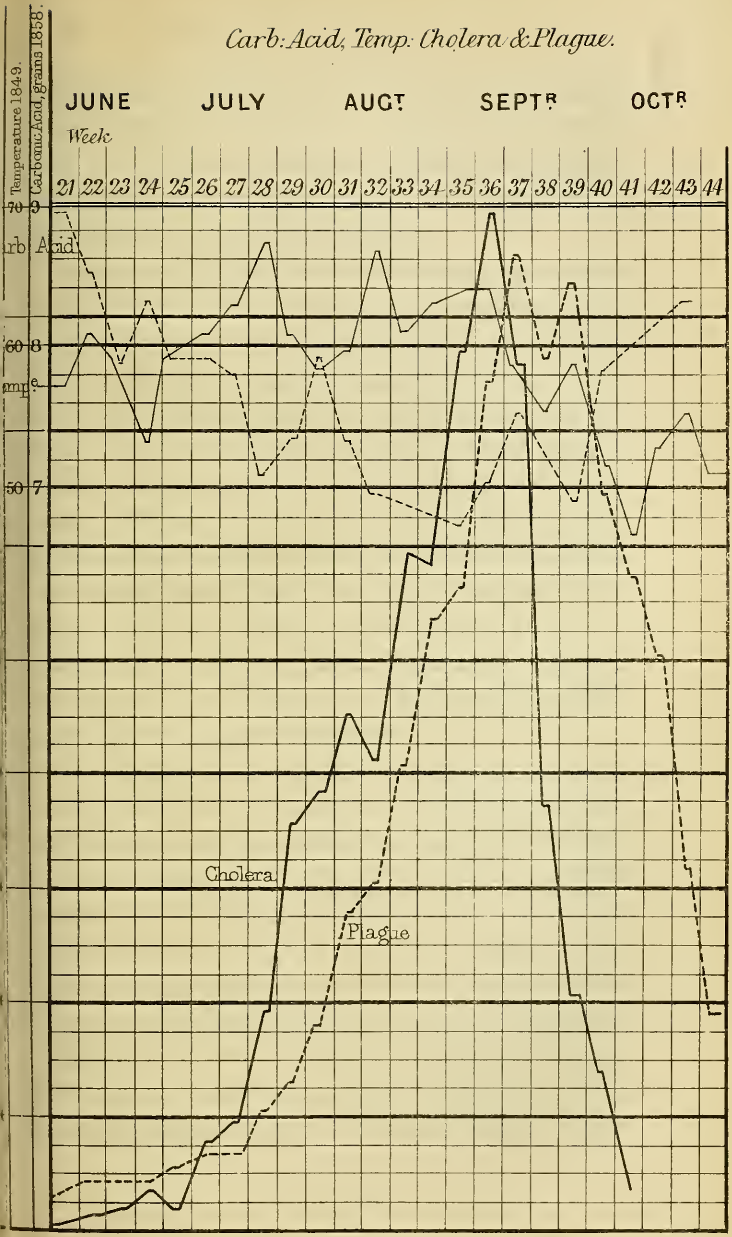
426. So, in like manner, with regard to pulmonary diseases of an inflammatory type which prevail in the winter and early spring. They are removed, so far as they are capable of being removed, by the new conditions of summer, which, with lessened vital changes, freer action of the skin, less force of circulation, and less direct irritation from the admitted air, offer the very conditions which the case manifestly needs.

427. But the most striking illustration, perhaps, is the cessation of a fatal epidemic, as the plague or cholera; for as its origin is obscure and its progress frightful, so is its disappearance unaccounted for. The direction of inquiry has had reference to the specific material which caused the disease, and to the diminution in number of those persons who are most liable to its influence; and no doubt both of these are worthy of investigation; for it has been shown that almost contiguous localities have been variously visited by the pest (which would seem to support the idea of a local origin), and it is admitted that men differ in their powers of resisting special morbid influences. We would not wish to withdraw attention from these two sources of inquiry, but it may be inferred that there is yet a further cause from the fact that in the same place, with the same population, and without any general preventive measures being adopted, the epidemic pursues a defined course, and at length ceases. In this case only the latter theory can be advanced in

explanation of the cessation of the epidemic, but it is manifestly too hypothetical to warrant our resting an important scientific question upon it alone.

428. The explanation which is required is found in that which has been already stated by us, viz. the changes of the vital powers of the body connected with season. The precise progress of the epidemic is that of the varying powers of the system. It begins as they decline, increases as they decrease, is the greatest where they are the least, decreases as they increase, and disappears when they have recovered the height from which they fell. These facts are delineated in Diagram No. 10, which shows in contrast the temperature, amount of carbonic acid evolved per minute, mortality from cholera, 1849, and from plague, 1665, during each week from June to October. The accord of the line of the temperature with that of mortality and the divergence of the lines of temperature and carbonic acid are very striking. This minute correspondence is so remarkable that it must show that there is an essential connection between them—one which overrides and acts independently of the two circumstances just referred to.

429. At present our chief difficulty is in accounting for the origin of such diseases, and the greatest labour and ingenuity have been expended to show that it is due to the introduction of special but undiscovered poisons. But we may be allowed to ask, if its presence will cause the outbreak, and it is multiplied as its victims increase, why does it not continue, and conti-


Carb: Acid, Temp: Cholera & Plague.
Temperature 1849.
Carbonic Acid, grains 1858.
JUNE
JULY
AUGT
SEPTR
OCTR
Week
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
70 9
60 8
50 7
rb Acid
mpe
Cholera
Plague

nually increase indefinitely? In the present state of our knowledge it is impossible to discuss this question with profit; but we venture to think that the idea which we have now given may be also applicable to account for the origin of the disease.

430. It will be observed that the same line of reasoning, or of inquiry, is called for in reference to all similar epidemics at various periods of the world's history, by whatever names they may have been called; for, however different they may have been in some of their manifestations, they all agree in causing rapid death from exhaustion, by the sudden failure of the vital powers. Hence we have not to investigate the origin of any particular disease known by a distinctive name, but a condition of system known by any name, in which there is most rapid and extreme failure of the vital powers. We may, therefore, take a wide view, and regard all such diseases as being essentially allied, and having an origin in common.

431. We have seen that with variation of season there is a variation of vital power in a definite degree, and that when sudden changes of season occur there are also sudden and extreme changes in the vital powers. It is also known that years vary in the character of some of their seasons, so that we may have an excessively hot and dry, or a cold and wet summer, and if there be a variation in the vital power according to the variation of the external phenomena, there must be an equal variation in the state of the system in different years. We have already stated

that we do not at present know all the external phenomena which enter into the conditions of season, neither do we know the precise action of some of them upon the human system; but it is sufficient to take them as a whole, and we may affirm that whatever may be the phenomena of the summer season, an unusual increase in their power must be attended by an unusual increase of their effects upon the system. The period may arrive when some investigator may carry the inquiry through a series of years, which we have made through the seasons of one year, and then we shall discover not only the effect of the cycle of the seasons, but the influence of the cycle of years; and as the sum of the cycle of the seasons in one year makes a total amount of vital action, so will that total amount vary as the sum of the several years varies.

432. That cholera years have noticeable peculiarities has already been ascertained, such as long continued high temperature, with great dryness and light winds, and there are some grounds for believing in variable electrical and ozonising conditions; but as this branch of knowledge is exceedingly imperfect, we must not withdraw our attention from the seasonal conditions as a whole, until we can fix upon the precise elements which may be causative of the effects which we investigate. On the whole, in cholera years there is an excess of the seasonal conditions of the summer; and as cholera advances over the globe by somewhat slow steps, and after attacking various places, soon retires, it is

not improbable that there may be an accumulative influence in these seasonal phenomena occupying two or more years in a cycle. By these various methods the human system would be progressively lowered until that point is attained in which sudden exhaustion may be easily induced.

433. We do not purpose here to enter into a consideration of the nature of cholera, or of its precise mode of attack, or we might show that there are at least two grand categories of cases, in one only of which is there a most excessive action of the skin, by which the temperature is directly and most rapidly lowered, but it is probable that however different the manifestations may be, all the cases are due to a common and general cause.

434. By this theory, moreover, we rationally account for the escape of persons placed in the midst of this disease, and for the prejudicial influence of fear, grief, anxiety, excessive exertion, and disordering food, in increasing the liability to attack, for in reference to the former, persons vary in the amount of vital power, and as to the latter, the circumstances named directly tend to lessen vital force in all men.

435. Hence we think we have shown that the method which Nature uses in the arrest of an epidemic and the cure of disease is one based upon the ordinary action of external phenomena upon healthy and diseased men alike, and one ever acting and ever tending in the direction of health.

436. *The daily habits of mankind are based upon the beneficial effects of change of season.*

437. It is a fact that change of weather is universally matter of common congratulation. We are never satisfied with that which we have, but are looking forward to that which is to come. If it be hot summer weather we anticipate the cool breezes of autumn; if it be winter we look forward to the spring; if we have cool and wet autumnal days we rejoice in the approach of the fixed cold of winter; and if it be spring with its warm showery days but cool nights, we long for the regular warmth and dryness of the summer. It may be said that this results from the defect in man's nature, from which we learn that

> "Man never is but always to be blessed,"

but it is not the result of caprice or mere desire for change—it is based upon the deeper cause of the necessity for variation in the degree of vital action in the human system; and the longer any condition has existed the more ardent are our desires for a change towards the opposite one. Hence in our daily experience we find that change of season removes conditions which are irksome and border upon disease.

438. *The beneficial action of the rotation of the seasons is the true foundation of expectant methods of medical treatment, and therefore of homœopathy.*

439. A common description of the expectant method is "leaving the case to Nature," and it is

effected by "watching the case," which implies that whatever changes are required, or at least expected, will be produced by the ordinary course of Nature's operations. The observation that a case in which debility is a leading feature will be improved by the approaching winter, or one of extreme sensibility and inflammatory tendency will be benefited by the summer, are acknowledgments of our reliance upon the ordinary processes of Nature, and that we expect such a change to take place in these processes as will remove the evils at present existing.

440. Since the periodic changes to which we have referred will come on certainly in the seasons themselves, and will proceed without any care or watchfulness on our part, we do well to confide in them; and in fact in reference to chronic disease we have little to do, but to remedy present ills and leave the future to the ordinary changes of Nature—the latter being the ground of hope for cure. This, it is said, is the foundation of the success of the great expectant system of the day—that by which attendance upon the case is pleasantly prolonged, until the seasonal operations of Nature shall have occurred and cured the patient.

441. *The kind of cases which are said to be especially fitted for homœopathy are those in which seasonal changes will necessarily lead to improvement of health.*

442. The sensitive nervous person who through the winter can scarcely bear the influence of the air at a temperature below 60°, and who consequently is

sheltered from it, may well find relief in the genial air and bright skies of summer, and then enjoy that exercise in the open air which had been so long denied to her. No more certain method of cure could have been devised—one devised, it may be, by the physician, but for which he should claim but little credit. In such a case a method of treatment which is not very disagreeable to the palate or to the habits of the patient, and especially one which has the charm of novelty (so much courted and even needed by persons who only enjoy a natural life during a small part of the year), cannot be without its admirers; and if the physician by good tact and agreeable manners can induce his patient to submit to a daily routine of visits, whilst the true physician is silently but surely bringing about the changes which will give relief, he must fulfil his mission. In such instances the difference between the two so-called *systems* of medicine is, that the one frankly, perhaps too bluntly, telling the patient that there is nothing of a serious nature in her case and that the summer will cure her, leaves her to the sole charge of Nature; whilst the other soothes her fears and flatters her hopes, and avoiding any plan of treatment which may excite disgust, amuses her until the true restorer has improved the health. Both indeed trust to a common help, but the one by his frankness offends his patient, whilst the other by his flattery gives the comfort which she needs. The one remains poor and the other becomes rich.

443. So again we might cite the case of the overworked clergyman, who with cares at home and anxieties abroad, enfeebles his system, and in his professional duties finds "the clergyman's sore throat." The support of himself and of his family, and his general power of usefulness, depend upon his health, and who so likely to be his medical attendant as he who by sympathy wins his heart, and by hopes gently expressed gains his confidence? The early summer will relieve his present condition and fulfil the promises of the medical man; whilst, if August should relax his system the approaching October will re-invigorate it, and thus by always soothing the present and pointing to the future, fears are allayed and hopes are periodically fulfilled. Moreover, a dogma with an appearance of profundity issuing from a broadly stated paradox appeals to his intelligence as well as to his faith, and becoming wise in this hidden wisdom he adds it to his treasures for distribution to his flock. He also of all men trusts in the wisdom of Nature's operations, but it is a trust of a general kind by which he hopes that she will further the efforts of the physician, and not that intelligent confidence which results from knowing that the operations of Nature will assuredly bring the relief in their natural course, and that the physician is of benefit chiefly by sustaining his hopes from season to season.

444. These, therefore, are illustrations of the abuse of the "expectant method," and do not in the least degree lessen our trust in it. It is only matter of

regret that the human mind generally is not so matured that it can at all times bear to receive the truth, but must be flattered by personal attention and comforting illusions.

445. *The period when there is the most evident effect from the expectant treatment is at the change of seasons.*

446. From what has been advanced, it will be understood that the changes in the vital actions proceed day by day throughout each season, but it will be clear that the earlier changes in each season have reference to the conditions left by the previous season, whilst the later ones by duration induce new conditions, which must themselves seek their relief in the next change of season. Therefore the commencement of each season (a season not necessarily reckoned by months) is the remedial period, whilst the end is the accumulative period; and when patients have reaped the benefit of the change we may fairly teach them to expect new evils, and then another beneficial change, and so on, through the seasons of successive years. It is then the province of the physician to point out to the patient the nature of the new conditions to be expected, or as we say, the "new phases of the disease," and the period when relief will in all probability arrive.

447. *The result of treatment in acute diseases varies with the period of the year.*

448. This has been strikingly seen in the various epidemics which have occurred, and particularly those of cholera, influenza, and scarlatina, in which it was

always remarked that the disease was most virulent at its first outbreak, and that after a time remedial agents appeared to be more efficacious. This has already been referred to under a former head, and without doubt is attributable to progressive seasonal changes.

449. It is also true with regard to the treatment of ordinary diseases, of which numerous cases occur in their season. Thus, for example, any condition of exhaustion appearing in July and August is far less amenable to treatment than one appearing at the beginning of September, and in practice we recognise this by our recommending the former mentioned patients to go to the seaside or to an elevated or northern region, where they may anticipate the good effects of autumnal weather, whilst the latter class remaining at home are soon restored to health. An inflammatory attack occurring at the end of spring is in like manner speedily relieved, whilst one of sub-acute pneumonia commencing in January is almost certain to endure until the following summer.

450. The ground for these statements is that already given, viz., that as disease is most commonly the result of an excess of seasonal conditions, it must follow that it will be most intractable whilst that excess exists, and the least so when it declines. No doubt there is a connexion between this idea and that involved in the statements of the excess of mortality, for if a disease be more intractable, it is very likely to be more fatal, and conversely; and hence the facts

brought to prove the latter might be adduced in support of the former.

451. When therefore we treat sthenic diseases in mid-winter we may not only treat them more energetically than in the autumn and in spring, but shall certainly find the attacks more prolonged, and particularly if the circumstances of the patient are such that he cannot command an artificial season. In the spring and autumn eruptive diseases will prevail and be intractable in proportion to the suddenness and violence of the contrast between the spring and summer seasons on the one hand, and the summer and autumnal seasons on the other. In the cases occurring in the early periods of such seasons we may act more vigorously than at a later period, so that in the spring diseases we may deplete, and in the autumnal diseases sustain freely, but we must beware of applying the results of this treatment to more advanced seasons. In the early months of summer we cannot use stimulating methods of treatment with the freedom which would be admissible at a later period, and indeed that is a period in which the expectant plan of treatment is specially necessary.

452. Under this head we may refer to the injurious consequences which are likely to follow from the example which has been recently offered in the administration of alcohols in a quantity with a perseverance and in a class of diseases heretofore unknown.[1] If we admit that alcohol is useful only in a

[1] Paper on the "Action of Alcohols in the Treatment of Disease."

certain condition of system, it is manifest that it cannot be proper all the year round, for the same conditions do not so prevail. The administration of alcohol at the end of summer and in the states of great exhaustion which then occur is borne extremely well, as has been often seen in the treatment of cholera, diarrhœa, diphtheria and certain stages of fever, in which diseases, females quite unused to alcohols have taken a bottle of wine or of brandy daily with evident advantage, or in a case under our own care, in which we administered six bottles of Port wine in forty-eight hours and saved the life of the patient; but it would be impossible to do this in the depth of winter or in the early spring, when the natural conditions of the body are totally different from those existing at the end of summer. If, therefore, in any disease of a more or less acute kind, as some forms of sub-acute pneumonia occurring in the summer season, it should be found by the disciples of Dr. Todd that alcohol can be borne without injury, we would urge them to beware of thence deducing that it will be equally innocuous if its exhibition be continued into the following winter. We have seen examples of this error, and would venture to urge upon such medical men the arguments which we have now adduced.

453. *The effect of remedies varies with the different periods of the year.*

454. It is scarcely possible to express the difficulty

—"Lancet," Feb. and March, 1861, and the "Transactions of the Medical Society of London," 1861.

which attends any investigation into the precise influence of medicines, although this seems to be the most satisfactory part of the duty of the physician, and one upon which many dogmatise with great authority. To do this implies that we are precisely acquainted with the state of the system and with the effect of all other agencies then acting upon it, so as to be able to eliminate the particular action of the medicine under examination, but it is well known that on none of these points have we the requisite information. Hence it is only where medicines have a definite, powerful, and rapid action, that we can isolate their effect from that of other agents, and hence it is also that different observers vary in their report of their action. Numberless remedies which have been employed at one era, with, as it was believed, a most useful effect, have been shown in other eras to be either without any power, or to be injurious, and yet all the observers appear to have been equally trustworthy. It is still so, and until we know more of the nature of diseased action, and the influence of external agencies, it will be wise to investigate this branch of knowledge with a sense of distrust.

455. There are those who attempt to determine the effect of remedies in incurable diseases by administering them singly to a number of cases in all stages indiscriminately, and to such as have been newly placed under improved hygienic conditions. The conditions of these several cases, therefore, differ, and no one remedy can produce common results; and hence the most

that can be affirmed is the valueless statement, that in a certain small number of cases the disease exhibited certain manifestations during the period when the drug was administered. But when the remedy is not directed to the removal of the essential cause or condition of the disease, but can only be adapted to some subordinate state, it is manifest that the so-called general results of treatment are not in any wise the effect of the remedy, but are simply co-ordinate and probably independent results. We cannot think that any physician is justified in administering one drug alone, as an acid or an alkali for example, in a number of cases selected simply by the name of disease, whether we regard the interests of science or those of the patient, for science can only be degraded, the remedial opportunity of the patient be lost, and the public confidence in the physician's intention to benefit the case be abused.

456. It is manifest that all such cases should be classed according to the indications which they present for the special treatment proposed; that the treatment should be continued without intermission until the internal conditions have been removed, and then should cease; that the external conditions should have been stationary for a certain period; that the results sought for should have reference only to the precise internal conditions which called for the special treatment; and that so large a number of cases should be included in the inquiry as will afford a large and comprehensive average.

457. And when all this has been effected there will yet be many sources of error, and amongst others those connected with the influence of season. Let us take iron, or any ordinary tonic and stimulating compound and administer it at the period of the year when the vital powers are high but in an individual then suffering from some state of debility, and we shall probably find that it will soon set up an artificial state of excitement, and must be discontinued; but if the same remedy be given at the end of summer, when the vital powers are very low, it will be borne with impunity; or if, in the former case, it should soon remove the temporary state of debility, in the latter it would fail to have any influence at all. So in reference to depressing agents, as tartarised antimony or purgatives. Their effect will be quite different in degree at the two opposite periods of the year, and hence will be borne very differently, as they may be administered at one or the other period. The former medicine may be tolerated when the vital actions are high and the skin inactive, but would probably produce irremediable exhaustion when the vital powers are low and the skin ready to act profusely.

458. Until recently it was too much the practice to look upon diseases as separate entities, and because they had a separate name it was considered that each needed a special method of treatment, and hence, if the same disease occurred in two different persons, or under different conditions, it was yet subject to one method of treatment. Now we begin to see the con-

ditions which are common to numerous diseases, and setting aside the distinction of name, we seek the essential condition, and apply our remedies chiefly to it. This great improvement is, however, as yet very imperfect in the direction now discussed; and there is still a common belief that the same diseased condition must be treated in the same way, whatever may be the period of the year at which it appears.

459. *The action of a remedy will appear to be very different as it acts with or against the natural tendency of the system at the period of its administration.*

460. If we administer a remedy which has an action corresponding with the influence of the season in which it is administered, it is very probable that it will appear to be efficient, but it may be that we are deceived, and that the whole effect was due to the operations of Nature. If it should oppose the natural tendency, we shall be apt to regard it as inert or inefficacious, whilst if it coincide with it we shall consider it as powerful and valuable; when in fact it is quite possible that we may err in both suppositions. Thus we find a reason for that diversity of statement as to the action of remedies to which we have already referred.

461. The rule undoubtedly is, that a remedy will appear to be more efficacious when its action corresponds with the changes which are naturally progressing. Thus a tonic will be found more efficacious at the autumnal period when the vital changes are beginning to increase; a febrifuge or a depletant in

the early summer because the two actions will coincide, but in truth in such states the action of the remedy was the least needed; whilst it will appear to be the least efficacious and require to be employed with greater vigour when it opposes the natural tendencies, and when its action is the most needed. Hence the necessity for a remedy and its apparent (but not real) efficiency are not parallel facts.

462. The dose of a medicine and its remedial influence must be determined, not only by the constitution of the patient and the urgency of the symptoms, but by the season of the year at which it is given, it being understood that the former should be greater and the latter appear to be less as the condition of the system is the more opposed to its special action; whilst a less dose and a better effect will be the conditions of its administration when its mode of action corresponds with the progressing change of the system.

463. Thus a less dose of stimulants and tonics will be required in winter and spring than in summer, whilst sedatives and depletants, including purgatives, require the contrary conditions.

Natural Astrology.

464. *Some knowledge of the effect of season was certainly the basis of the system of astrology, and the authority for the predictions of astrologers.*

465. We do not imply by this statement that

natural astrology was a system of truth, but only that its origin may have been based upon truth.

466. A reference to the heavenly bodies as signifying the hour is still common in all newly settled countries, so that the settlers in the western states of America say it is "so many hours by the sun," and not that it is "such an hour by the clock." In like manner the degree of elevation of the sun in winter and summer might readily be taken to indicate the seasons, and the immediate point of its rising as to whether it were quite easterly or south easterly may well mark spring and autumn. So again the constellations appear in definite order with each month of the year, and describe the progress of the seasons, and as in the constellations there are remarkable stars, such stars would be much regarded. In this language (which is indeed the language of man universally in the rudimentary state of society) the advent of a particular star or constellation in the end of summer might very well be connected with the peculiar liability to virulent disease which then prevailed, just as we may in more general terms connect season with it, or with the buoyancy of spring and the tonicity of winter. Whilst in every country there would be a correspondence between a certain season and disease, and thus all astrologers be agreed, there would be diversity as to the pleasure or the injury to be derived from each season according to the latitude of the locality, and thus astrologers might differ. The signs of the zodiac

were in eastern climes always associated with the season of the year, and thence by a natural association they became connected with the good or evil of that season, and in the still earlier ages of society they would be further regarded as the cause of that good or evil. The truths for which we have been contending throughout this chapter have been equally truths in all ages, and, in varying degrees, in all countries also. They have been also at all times equally open to observation, and that there were in the olden times observers of natural phenomena superior perhaps to any in our own day may be learnt from the writings of Pliny, Hippocrates, Galen, and Aretæus. With so much truth there would no doubt be mixed much mystery when it was formed into a system of learning, both from the common disposition of the learned to involve their knowledge in mystery, and from the ignorance and superstition of those to whom the learned addressed themselves.

467. We confess that with the enlightenment of our day we could see no impropriety in regarding the constellations of the Crab, the Lion, and the Virgin, with less favour than those of the Ram and the Bull, for the approach of the first series indicates the occurrence of a season when dire disease oftentimes prevails, and when the human system is on its downward course, whilst the latter introduces to us the budding spring, with all its healthfulness, vivacity, and vigour.

468. In the book of Job we find the Almighty asking, "Canst thou bind the sweet influences of

Pleiades, or loose the bands of Orion" (chap. xxxviii.); which in the comments of Bishop Hall and Dr. Warneford signifies, "Canst thou alter the seasons of the year, or cause a restraint of the spring, summer, &c.?" And again, Job says of the Almighty (chap. ix.), "Which maketh Arcturus, Orion, and Pleiades, and the chambers of the south," which clearly means the four seasons of the year. The Pleiades rose in spring, when Nature is most active and cheerful. Orion rose about the end of November, and continued a striking object until January, marking the whole winter, and having a name in Hebrew which itself denotes unsettled weather. Arcturus rose in September, when in Palestine the nights were cold and the days warm, and represents autumn—the beginning of the year in eastern nations.

469. This is a mode of expressing thoughts which is not only the most elegant and expressive, but which would be the most natural to nomadic and pastoral tribes in the earlier ages of the world, and we do not know that the present mode by which we express ourselves, viz., by the terms "months" and "seasons," conveys any more intelligible information. If we say that we shiver under Aquarius, and are burnt up under Gemini, is it not as correct as to say that we have summer and winter? If, moreover, it be true, as we have endeavoured to show, that the viability of children varies with the season of their birth (329), and this had been known to some of the good observers of antiquity, it is easy to see how a dread,

hardly superstitious, would be connected with the constellations which marked that period of the year. There has undoubtedly been truth at the basis of every system of knowledge which has prevailed amongst men, but it has ever had the misfortune to become clouded with falsehood as converts have been made, and the selfishness and guile of men have built a fabric of human desire upon its immutable basis. Such, it is probable, has been the character and the fate of astrology—a system which occupied the attention and engaged the faith of Kepler, and multitudes of intelligent and able men, and it is not improbable that they had as much truth as the basis of their belief as we have in many systems of knowledge which prevail in our day.

470. The renowned John Kepler remarked: "I repent bitterly having so much decried astrology," and although he lived in a superstitious age, he was a man who relied too much upon facts, and knew too much about the relations of the heavens to the seasons to warrant our treating his opinion with contempt; but as we do not purpose to attach great importance to this subject or to devote much space to its discussion, we will now only offer a few observations upon the reference which is made at the present day to the heavens in connection with disease, and the association which according to astrology existed between certain diseases and the appearance of the heavenly bodies.

471. The influence of the moon upon the "Moon

Fever" in India is now settled beyond all doubt, as may be seen by the writings of Dr. Balfour, and the very recent observations made at the Royal Medico-Chirurgical Society by Dr. Webb, of the Bengal Medical Service, on December 11, 1860.

472. We thoroughly admit the influence of the sun in the amount of light and heat and chemical influence which he exerts over all animal and vegetable organisms, and over various meteorological phenomena which in a secondary manner affect us. In reference to heat we well know the evil effects of excessive summer temperature, and although we are aware that the effect of the heat is varied by the motion and the hygrometric conditions of the air, yet the usual reference to our thermometers in sheltered places tells us that we practically regard the sun as the chief author of all the good or evil which heat induces. The peculiarities of various latitudes in relation to the well-being of man are well established, and these depend mainly upon the lessened or increased influence of the sun in those positions.

473. We have shown in the former part of this chapter that in our own climate the kind and prevalence of disease vary with each season, and nothing is better understood and admitted than this fact. But the term season is, as we have shown (256), more or less indefinite, and is not rigorously limited. Thus the Registrar-General includes in the spring the months of April, May, and June, from the first to the last day of these months; but meteorologists and

astronomers reckon spring to commence at the spring equinoxes, and to extend to the summer solstice. Whilst, therefore, there is an advantage in the use of a term which comprehends so large a part of the year, we do not see that we have attained to more precision than was known in distant ages, when the signs of the zodiac were employed, and as the conditions which mark each period vary greatly in the course of three months, we necessarily mix up diverse influences in the general idea thus obtained.

474. Let us for a moment turn to the connexion which the astrologists found between the occurrence of particular diseases and the signs of the zodiac, bearing in mind the month which each sign represents, and allowing that latitude to the various months which we permit in our combined idea of the seasons, as associated with the occurrence of disease.

475. The following is extracted from works published in the 17th century:

	Spring.			Summer.		
Sign	Aries.	Taurus.	Gemini.	Cancer.	Leo.	Virgo.
Month	April.	May.	June.	July.	August.	Sept.
	Autumn.			Winter.		
Sign	Libra.	Scorpio.	Sagitt.	Capric.	Aquar.	Pisces.
Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.

Aries . .	Skin diseases and sun-burning ; perhaps small-pox and measles ; diseases of the head and nerves.
Taurus . .	Disease of the throat.

Gemini .	Diseases from blood-letting; diseases of the blood.
Cancer . .	Want of appetite; dropsies; coughs; affections of the stomach and liver.
Leo . .	Affections of the heart; fever; jaundice; pestilence; all disease of choler.
Virgo . .	Disease of the bowels; cholic and Iliac passions; affections of the spleen; melancholy.
Libra . .	Diseases of the kidneys; gravel; diseases from corruptions of blood.
Scorpio . .	Diseases of the kidneys and the womb.
Sagittarius .	Sciatica; pestilential fevers; heat of blood.
Capricornus.	Skin diseases; accidents; melancholy; and discharges.
Aquarius .	Cramps.
Pisces . .	Chilblains; gout; skin diseases; small-pox; measles; all cold and moist diseases; and such as come by catching wet and cold feet, which lead on to the affections of the head under Aries.

476. Thus we find skin diseases recorded in January, March, and April; fevers in August and December; kidney disease in October and November; bowels and liver diseases in July, August, and September; throat diseases in May; defective nutrition in July; melancholy in September and January; discharges and affections from cold in January and March; rheumatic affections in December and February; heart diseases in August; diseases of the blood in June.

477. When this list is compared with that already given (393), it will be seen that there is a substantial agreement with the occurrence of disease in our own day. There was a conceit that the parts of the body were progressively affected from above downwards as the months advanced, beginning with

the head in April, and going to the throat in May, the stomach in July, the heart in August, the bowels in September, the kidneys and bladder in October, the hips (rheumatism) in December, and the feet (taking cold) in March, and although it is fanciful there is a correspondence between its principal parts and the actual prevalence of disease in these months.

478. The planets were, however, brought into the larger question of the seasons, so that Jupiter (winter) was said to rule the chest, Venus (spring) the functions of generation, and Mercury the part of the brain in which is the intelligence, &c.; but this part of the science is further removed from fact than that above indicated.

479. There is much to amuse, and perhaps something to instruct us in the discarded works to which we have referred; and, upon the whole, we believe that there was a substratum of truth in the doctrines of the astrologists, and that their mode of expressing themselves was as intelligible to them as is our present mode to ourselves; whilst the fancies into which they ran were due to the same disposition which led the Greeks and the Romans to find a multitude of gods, viz., the desire to personify each acting influence, and to ascribe to it a controlling instead of an indicating value. The signs of the zodiac may well describe the position of the earth in the sun's path, and thereby indicate the degree of influence of the sun upon the earth. We either do not ascribe the effects observed

to any single agent, or we refer them to the sun and limit them by months; whereas the astrologers, in appearance or in reality, ascribed them to the signs of the zodiac and to the planets in their courses.

CYCLE OF THE AGES OF MAN.

CHAPTER VII.

ASCENDING SERIES.

INFANCY.

480. We do not wish to discuss any critical objections which might be taken to the heading of this part of our subject. It might fairly be objected that the changes which occur from infancy to old age are not those of a cycle but of a curve, the ends of which cannot approximate, for it is a sketch of the imagination in which we see the child again in the second childhood of man. Whilst admitting this, we yet hope to show that there is a progression of phenomena connected with every man which may not improperly be called cyclical, whether in reference to himself or to his position as an unit of a countless mass; but however this may be, we purpose to describe the progression of the principal vital phenomena which occur in the successive ages into which man's life is familiarly divided, and to elicit such practical truths as they may readily afford.

481. The processes occurring in the body of man are commonly divided into an ascending and descending series; but some would interpose a third condition, in which these two tendencies so nearly counterbalance each other that a *status quo* may be said to exist for a certain period in the mid-life of man. The ascending series includes the period of growth, and the full development and perfection of the animal frame, and in this the formative is always more powerful than the destructive process; whilst the descending commences where the ascending ends, and is marked by a deficiency of the formative process. There is no halting ground between these two conditions, for from birth to death the two processes are ever antagonistic, and as the one fails the other advances. We propose to consider the ascending and descending series in their order, and in the former shall discuss the conditions of infancy, childhood, and adult life.

482. *The characteristic of infantile life is the maximum of rapidity of the vital functions, and the minimum of resistance to adverse influences.*

483. The pulsation at birth is 130 to 140 per minute, and even at the end of the first year of life is still 115 to 130 per minute, whilst the rate of respiration is 30 and 25 per minute at those two periods, as shown in the table No. 36, page 262.

484. The cause of this extreme rapidity is primarily associated with that of pulsation, for the connection between these two functions is such that if the pul-

sation be increased, the respiration must increase also, whilst the rate of respiration may be voluntarily increased without any material effect being produced upon the pulsation, as any one may prove upon his own person. Hence the dependence of the two upon each other is rather that of respiration upon pulsation, and this leads to the inference that the supply of blood to the lungs is one of the chief excitants of the respiratory action. The rule is "as is the rapidity of the heart's action, or the supply of blood to the lungs, so should be the movement of the lungs."

485. *Rapidity of pulsation is associated with shortness of the circuit of the blood.*

486. The cause of this rapidity of pulsation has been explained by the general expression of the necessity for a large amount of vital action to meet the requirements of the infantile system in the direction of growth; but such statements are simply parallel facts, and not explanations. There must be a physical cause for this rapidity, and a dependance of it upon a physical action, which it should be our duty to trace.

487. The shortness of the circuit of the blood is doubtless one of the elements of this causation. It has been established that the rate lessens as the human system advances in growth, and also that in tall persons the rate is less than in those of short stature, and so general is this latter law that in the inquiry into the daily rate of these functions in 15 consumptive patients, already described (36), the rate

of both functions even in disease lessened with increasing stature. Only in this manner can we account for the diminution of the rate as infancy merges into childhood, for at the latter period the other cause, viz., the necessity for growth, is then quite as powerful as in infancy. With a short circuit the blood must return more quickly to the heart, if the forces which maintain the circulation are the same in infantile as in adult life.

488. The waste of heat is doubtless another link in this chain of causation. The skin of the infant, so soft and vascular, must act very freely and cause a larger proportionate dispersion of heat than occurs in later life, and hence in order to maintain a due amount of heat at the surface, it follows that a larger proportion of blood must be supplied to it, and as the volume of blood in the vessels does not very materially vary, the rapidity of the circulation must be increased.

489. In all questions of this nature we must bear in mind that each race of creatures has its own vital laws implanted in it, which are in our imperfect ideas called its nature, so that although the law of length of circuit may be correct when applied to the different sizes of the human race, it does not follow that all creatures can be indiscriminately compared with each other, and that the size of an infant and bird and the rate of the functions of the former being given, the rate in the latter may be found.

490. It might easily be shown that rapidity of circulation, conjoined with due rapidity of respiration, is

conducive to the rapid and complete elaboration of the blood, and that where these are conjoined with abundant nutritive material to be transformed, the result will be great vital action, and in the infant—growth.

491. The feeble power possessed by infants to resist adverse influences must render them peculiarly prone to submit to the evil influences of season. Hence infant mortality is a marked feature in the death-roll at all seasons, whether it be in the cold of winter from inflammation and exhaustion, in the heat of summer from debility, or at the change of the seasons, when they are the victims of the many antagonistic changes before described.

492. It is, therefore, a duty to give the utmost degree of attention to prevent the exposure of infants to the conditions which mark the extremes of each season, whilst at the same time it has been shown that a due degree of exposure to the varied conditions of each season is conducive to health.

493. *There is in the infant the maximum of oxidation of the elements of nutrition, and the maximum of highly organised food supplied.*

494. The first part of this proposition is proved by the state of the respiration, for both Vierordt and ourself have proved that with rapid respiration there is a larger amount of carbonic acid formed per minute than under other conditions. This is primarily owing to the disengagement of the carbonic acid from the blood, on the simple principle of admixture of gases;

but secondarily it must lead to an increase of those vital changes by which carbonic acid is given to the blood.

495. The blood in infancy has rarely been subjected to chemical analysis, and we shall refer to the subject again presently in connection with childhood. Denis found that the blood of the fœtus was richer in solid constituents than that of the mother. In 1000 parts of blood taken from the umbilical artery, and 1000 parts taken from the venous system of the mother, it was found that the blood corpuscles were 222 in the former, and 139·9 in the latter, whilst that of the solid residue was 298·5 in the former, and 219 in the latter. The following table, No. 32, gives the details of the analysis, and it is interesting to note how much larger is the amount of iron in the blood of fœtal than in that of mature life. The amount of albumen, fibrin, and salts was nearly equal in the two conditions, whilst phosphorised fat and some other elements were more abundant in the mother.

496. With the very large amount of blood corpuscles and of iron existing in infant life, there must be an unusual capacity for the carrying of oxygen in the circulation, and for the oxidation of food elements.

497. *The food taken by infants is in proportion to the weight of the body from three to six times greater than that taken by adults.*

498. The large amount of highly organised food taken by the infant will be the most readily appreciated by comparing the amount of food which it takes with

the weight of its body, and then contrasting this result with the conditions of adult life.

TABLE No. 30,
SHOWING THE CONSTITUENTS OF FŒTAL AND THE MOTHER'S BLOOD.
(Simon's Chemistry, p. 338, vol. i.)

	Venous Blood of Mother.	Blood of Umbilical Artery.
Water	781·	701·5
Solid residue . . .	219·	298·5
Fibrin	2·4	2·2
Albumen	50·	50·
Blood corpuscles . .	139·9	222·
Peroxide of iron . .	·8	2·
Phosphorised fat . .	9·2	7·5
Osmazome and cruorin .	4·2	2·7
Salts	12·5	12·1

499. In numerous analyses of human milk, made by Simon, the maximum and minimum quantities of the various constituents were as follows, in 1000 parts.

TABLE No. 31.

	Maximum.	Minimum.
Water	914·	861·4
Solids	138·6	86·
Butter	54·	8·
Casein	45·2	19·6
Sugar of milk and extractives .	62·4	39·2
Fixed salts	2·7	1·6

500. These numbers are very widely apart, and cannot of themselves give us the data which we need; but from a reference to many other recorded analyses we may consider that good human milk contains $3\frac{1}{2}$ per cent. of butter, $3\frac{1}{2}$ per cent. of casein, and 4 per cent. of sugar of milk.

501. It is very difficult to determine the quantity of milk which an infant of 3 months old takes in the 24 hours, and, perhaps, equally difficult to determine how much of that which it does take is retained and assimilated; but we shall not exceed the quantity if we state it at 3 pints. That quantity weighs 26250 grains, and contains on the above estimation 2 ounces and 44 grains avoird. each of butter and cheese, and more than $2\frac{1}{4}$ ounces of sugar.

502. In estimating the value of these figures we shall regard the fat as equivalent to $2\frac{1}{2}$ times its weight of starch, and then the constituents may be arranged thus:—

TABLE No. 32.

$5\frac{1}{4}$ ounces of starch, of the formula .	C 44·44,	H 6·17,	O 49·39,	N 0
$2\frac{1}{10}$ ounces casein, ditto.	C 53·83,	H 7·15,	O 23·37,	N 15·65
$4\frac{1}{3}$,, milk sugar, do.	C 40·,	H 6·6,	O 53·4,	N 0

503. When the quantities are reduced, we find the weight of the ultimate elements in grains as follows:—[1]

[1] The quantity of the elements in starch, casein, and milk sugar in accordance with the above formulæ may be readily ascertained by dividing the total weight by the following sums:—

TABLE No. 33.

In the starch (grains) .	C 1022·	H 141·5	N 0·
,, ,, sugar ,, .	420·	61·	0·
,, ,, casein ,, .	494·	66·	144·
Grains .	1936·	268·5	144·

or 4·42 ounces avoird. of carbon, ·614 ounces of hydrogen, and ·3 ounces of nitrogen.

504. If we then assume the average weight of an infant of three months of age to be 14 lbs., we have a daily consumption of 136 grains of carbon, 19·1 grains of hydrogen, and 10·4 grains of nitrogen for each lb. weight of the child.

505. In like manner let 140 lbs. represent the weight of a man somewhat below the average, or 10 times the weight of the infant, and if he were fed in the same proportion he would require 44·2 ounces of carbon, 6·14 ounces of hydrogen, and 3· ounces of nitrogen per day. But what is the fact?

506. Let us again assume that an ordinary man will consume daily bread and flour equal to 2 lbs. of bread, also $\frac{1}{2}$ lb. of potatoes, 6 ounces of uncooked meat, $1\frac{1}{2}$ ounce of sugar, and $1\frac{1}{2}$ ounce of butter,

Starch :	to find the amount of	carbon,	divide by	2·247
,,	,,	hydrogen	,,	16·2
Casein :	,,	carbon	,,	1·857
,,	,,	hydrogen	,,	14·
,,	,,	nitrogen	,,	6·39
Milk Sugar :	,,	carbon	,,	2·5
,,	,,	hydrogen	,,	15·15

and the total carbon and nitrogen (omitting the hydrogen) will be as follows :—

TABLE No. 34.

	Carbon.	Nitrogen.
Bread	oz. 9·61	grains 174[1]
Potato	,, ·8	,, 16
Meat	,, 1·8	,, 54
Sugar	,, ·6	
Butter	,, 1·1	
	oz. 13·91	grains 244

[1] The following is a useful formula, and is chiefly derived from Playfair's data :—

	Parts equal in Carbon to 10 parts of fresh bread.	Nitrogen in each ounce. Grains.
Bread	—	$5\frac{3}{4}$
Wheat Flour	8	$7\frac{3}{4}$
Peas	8	$15\frac{3}{4}$
Rice	8	$4\frac{1}{3}$
Oatmeal	$7\frac{1}{2}$	$8\frac{3}{4}$
Scotch Barley	—	—
Molasses	—	—
Meat, fresh	10	$8\frac{3}{4}$
Cocoa	5	$8\frac{3}{4}$
Potato	30	$1\frac{1}{2}$
Suet or Butter	$4\frac{1}{2}$	—
Sugar	$7\frac{1}{2}$	—
Indian Corn	$7\frac{1}{2}$	$7\frac{3}{4}$
Cheese	8	$19\frac{1}{2}$

The average weight of an infant at birth is between 6 and 8 lbs., and is greater in males than in females, and varies somewhat in different countries. In France, Chossier found, as the result of 20,000 weighings, that the average weight at birth was $6\frac{3}{4}$ lbs.

507. Hence, a well-fed adult consumes daily, for every lb. weight of his body, $43\frac{1}{2}$ grains of carbon and $1\frac{3}{4}$ grain of nitrogen, whilst the infant consumes, for every lb. of its weight, 136 grains of carbon and 10·4 grains of nitrogen; the amount being in the infant 3 times greater in carbon and 6 times greater in nitrogen.

508. We have not in this calculation considered all the elements of the milk, neither have we burdened it with minutiæ, but it is sufficiently exact for the purpose which we have in view, and proves, in a most striking manner, our proposition, that the infant requires the maximum of food.

509. *The substitution of starch for milk lowers the amount of nitrogen supplied.*

510. It will have been observed, from the figures just given, that the proportion of nitrogen supplied to the infant as compared with the adult is much greater than that of carbon, a circumstance which has its significance, not only in supplying material for muscular and albuminous tissues, but in the rapid and complete transformation of the hydro-carbons. We have elsewhere shown that nitrogenous compounds have both of these actions, and there can be no doubt that the casein in milk is as important in the latter as in the former capacity. The necessity for this great excess of nitrogen in infantile life is no doubt dependent upon the necessary rapidity of all the vital actions, and the absence of exertion, which is the natural excitant of the

transforming as of every other vital process within the body.

511. When duly considering the facts now given, and admitting the fitness and necessity of the kind of food which Nature has universally provided for the young, we shall perceive the ill effect of supplanting a part of the natural milk by any farinaceous food; we say *supplanting,* because we assume that if such food be added, the infant will be unable to take so much of the milk. In bread the proportion of nitrogen to the carbon is as 1 to 22, whilst in milk that proportion is doubled and becomes as 1 to 11, and consequently the supplanting of the latter by the former would be to reduce the amount of nitrogen and increase the amount of carbon supplied to the infant, and hence the necessity which the absence of exertion imposes of supplying a highly nitrogenous food to aid in the transformation of the hydro-carbons would be insufficiently met, whilst the carbon would be in excess.

512. A further objection might be taken to the addition of starch by regarding its transformations and the inadequate power of the processes of digestion and assimilation in the infant to effect them with a rapidity sufficient to meet the wants of the system, but this is better met by referring to the provision which Nature has made for the young of animals in the milk with which the mother is supplied, and which must thence be regarded as the proper type of infants' food. When the conditions of infancy change and muscular power

is exercised, then it is probable that the relative amount of nitrogen may be lessened, as it seems naturally to be as the child advances towards maturity, and starch may partly supplant this more highly organised food.

513. *The dangers in infant life from without are at their maximum, and are chiefly connected with temperature.*

514. The free action of the skin, to which we have referred, together with the absence of exertion, tend to the rapid dispersion of heat from the body, and do not provide for the increased distribution of it to the surface when there is danger of the waste of heat being too great. The sedative influence of cold is well known, and when exerted on the sensitive system of an infant, rapidly depresses the vital actions below that amount which we have shown to be necessary for its well-being. Moreover, when by exposure to cold, the capillaries of the skin become contracted, there must be an unusual determination of blood to the internal organs, and inflammation of the lungs or head disease are very likely to follow.

515. The ill effects of the want of care in the management of infants are now better known than they were formerly, and care is more generally taken to clothe them well and to keep them in a moderate degree of temperature, yet it is very common to see the very young children of the poor carried in the streets by children scarcely older than themselves, when ill-clad and in wintry weather. In the opposite class

of society it is becoming too fashionable to allow the infant to sleep by itself through the cold nights, and, since the warmth of the body of the nurse or mother is far more valuable to the infant than mere clothing, we would strongly object to the plan of leaving the infant to sleep alone in the cold season.

516. The exposure of the skin to the air soon induces a drier and rougher state of that organ, a condition in which it is less sensitive and less active, and therefore, within due limits, exposure may be beneficial, but there is much more liability to danger from deficiency than from excess of temperature.

517. *The dangers from within are chiefly those resulting from wrong feeding and excess of sensibility.*

518. When there is a deficient amount of food supplied to the infant, as would be the case in the woman who yielded the minimum analysis of milk described in Table 31, inanition must follow. In that case the amount of fat was reduced to less than one-fourth of that which ought to have been supplied, whilst the deficiency in the casein was at least one-half, and hence both the carbon and the nitrogen would be greatly deficient. It is a too common error to believe that the amount of nutriment which the child obtains may be measured by the quantity of milk which the nurse can yield, and hence, although the infant may become emaciated, the disease is not ascribed to the efficient cause. It is doubtless very difficult—we may say impossible—to analyse the milk of every nurse whose child is not thriving well, but if it were more constantly

borne in mind that the amount of the nutritive elements of milk does vary very greatly in different persons, it would suffice to direct attention to this probable cause of defective nutrition. Whenever an infant does not grow in the usual degree, or is peevish, and perhaps emaciated, it is of prime importance to taste and examine the milk, with a view to ascertain if sufficient nutriment is being supplied by the nurse, and if needs be to use the *experimentum crucis* of procuring an additional supply of milk from another source.

519. In inquiries of this nature we must remember that as the age of the infant increases new wants arise, and a new kind of dietary is called for. Hence it occurred to Professor Simon that variations of a definite character would be found in the milk of the nurse at succeeding periods of lactation, and he made an analysis of that fluid from a period soon after the accouchement in August to the beginning of January. He showed that the quantity of casein was at its minimum at first, and increased considerably, whilst the converse was true in reference to sugar. Butter was a very variable constituent.

520. We append the results of his analysis, but it must be remarked that it was impossible to keep the dietary of the nurse uniform, and that changes of composition might have been more justly expected at a later period that that at which his inquiries terminated.

521. The other extreme, or the supply of too much

TABLE No. 35.

SHOWING THE CHANGES IN THE COMPOSITION OF HUMAN MILK DURING LACTATION.

Date.		In each 1000 Parts. Casein.	Sugar.	Butter.	Fixed Salts.
August	31	21·2	62·4	34·6	0·84
September	7	19·6	57·6	31·4	1·66
,,	8	25·7	52·3	18·	2·
,,	14	22·	52·	26·4	1·78
October	27	43·	45·	14·	2·74
November	3	45·2	39·2	27·4	2·87
,,	11	35·3	39·5	8·	2·4
,,	18	37·	45·4	34·	2·5
,,	25	38·5	47·5	14·	2·7
December	1	39·	49·	8·	2·08
,,	8	41·	43·	22·	2·76
,,	16	42·	44·	20·	2·68
,,	31	31·	52·	54·	2·35
January	4	40·	46·	37·	2·7

nutriment, by a milk which is unusually generous merits attention, but it is much more rare to see an infant who suffers from true excess than from defect. The powers of adaptation which the child possesses by passing excess of food through the bowel or by vomiting, seem to be a ready and sufficient guard against the evils of excess.

522. *The most frequent source of evil is the substitution of the milk of animals, farinaceous food, cream and water, and arrowroot and water, for that which*

Nature has supplied, and which, not being so well adapted to the assimilative powers of the infant, are liable to be in excess, and yet at the same time to impoverish the child.

523. Thus in the substitution of cows' milk for that of the mother, there is danger of an excess of carbon occurring from the increased quantity of fat, or if goats' milk be given there may be danger of the excess of the casein ferment. The first-mentioned danger is one which is more familiar to us than the second, for it is known that excess of fat, or carbon, is apt to deteriorate the vital properties of the blood and to load the portal circulation, but we do not know the results of excess of nitrogen in the production of disease. The former condition soon induces vomiting and loss of appetite, whereby the excess is ultimately removed, and the latter, in more advanced life, passes off in the form of urea, but we do not know much respecting its occurrence in infants.

524. The administration of farinaceous food is apt to supply a material, which from the want of due and rapid transformation may remain in excess, whilst at the same time the amount of nutriment available from moment to moment is insufficient. Disordered bowels is the first condition in the direction of disease in these cases, and by the evolution of gases, distension and painful spasm of the bowel succeed, which in themselves tend to exhaustion, to internal congestion, and increased waste of heat. Such cannot with propriety be called excess of feeding, but rather the supplying of inappropriate food, and we have often

seen infants of a year old passing very large stools of undigested starch when fed in that manner. As a period must arrive when farinaceous food ought to be given, and as from accidental occurrences the nurse's milk may prematurely fail, and other food be required, it is important to bear in mind that the fœcal evacuation offers a very good guide both as to the amount of assimilation proceeding in the system, and the excess of this starchy food. If the stools be voluminous, it is manifest that one or both of those conditions exist, and a diminution of the starch with or without increase of the milk is indicated.

525. It is not infrequent to find infants fed on cream and water under the belief that the curd is injurious, and that more fat is required by the system; and again there are many who use cows' milk diluted with two or three parts of water. In reference to the former, we may affirm that no surer way of emaciating the child could be devised, for by the absence of the sugar and casein the due transformation of food is prevented, and cream alone is quite insufficient to nourish the system. The latter method has the same evil, but in a less degree, and although the addition of water and sugar of milk to cows' milk may be defended, we should take care that the fat and casein are not reduced to 3 or below 4 per cent.

526. A greater evil than this, however, is the administration of arrowroot with water as the chief or sole source of nutriment. We have already shown that the carbon supplied to an infant which takes three

pints of milk daily is, in the fat of the milk only, equal to $5\frac{1}{4}$ ounces of starch, and as arrowroot is nearly pure starch, we may state that $5\frac{1}{2}$ ounces of arrowroot would be required to meet that want daily; but as the carbon in the casein and sugar is equal to $\frac{8}{10}$ of that contained in the fat, it would require nearly 9 ounces of arrowroot per day to supply the wants of the infant. Now we know that those who feed their infants in this way do not give more than 1 or $1\frac{1}{2}$ ounce of arrowroot per day, and hence the child must be starved to death from mere absence of nutriment. But in addition to this, we have shown elsewhere that starch alone does not increase the respiratory changes, and that there is needed a nitrogenous element for its transformation, and hence it is probable that a large portion of this small quantity is unassimilated. That such poor creatures must perish is inevitable.

527. The great sensitiveness of the infant system seems to be proved by the convulsions so frequently following irritation in any part of the system, as in the gums and the bowels, but it must be recollected that adults find toothache and cramp in the bowels amongst the most painful occurrences to which they are subjected, and difficult enough to bear. It is not easy to prove that there is greater sensibility in infantile than in adult life, although certain facts lend a presumption in that direction.

528. *It is not true that deposition of fat in the skin protects from cold and from other diseases.*

529. The excess of food in infantile life over that necessary to the adult is in part employed in the growth of the infant, and in part is temporarily deposited in the form of fat, and a child is usually regarded as in its most natural and healthy state when there is this deposit of fat.

530. The use of fat is no doubt found in the storing up within the system of a highly carbonaceous material which may at any time afford an unusual supply when there is an unusual demand for it, and therefore in this sense it will protect the system from some of the ill effects of exposure; for with increased need of heat there will be at hand the means of meeting the want, at least within certain limits. But in the ordinary sense of taking cold, the accumulation of fat in the skin certainly does not lessen the liability, but in all probability somewhat adds to it. The skin of a fat person is for the most part soft, and perspiration is easily excited. It is also abundantly supplied with blood, and therefore will not be deficient in sensibility, and hence it exposes the body to all the evils resulting from excessive waste of heat and from the action of sudden cold upon the skin.

531. In all diseases in which the balance of the circulation is largely disturbed, it is commonly observed that excess of fat increases the evil, and probably this may be explained by the disproportionately large amount of blood which is usually distributed to the surface in such cases; for in the event of circumstances occurring in which blood is not formed in

due quantity, there will be a defect at the centres, whilst on the other hand if the large amount of blood commonly distributed to the skin be directed inwards, repletion and congestion of the internal organs must occur. In cases of feeble heart, there is greater danger of a disturbed balance of the circulation in fat persons than in others.

CHILDHOOD TO ADULT LIFE.

532. We will now proceed to trace the variations in the condition of the human body which occur through the long and important period which separates infancy from manhood, for although there are certain external signs which clearly mark the intermediate era of puberty, there is not any distinction in the vital process which clearly separates that from the immediately preceding and succeeding periods.

533. *The rate of all the functions of the body subsides from childhood to adult life.*

534. The diminution in the rate of pulsation at intervals of a few years may be learnt approximately from the following table :—

TABLE No. 36,

SHOWING APPROXIMATIVELY THE RATE OF PULSATION FROM BIRTH TO OLD AGE.

Birth . . .	130 to 140	7th to 14th year .	80 to 90
End of 1st year .	115 to 130	14th to 21st year .	75 to 85
,, 2nd year .	100 to 115	21st to 60th year .	70 to 75
,, 3rd year .	95 to 105	Old age . .	70 to 80

535. Thus the rate of pulsation diminishes yearly at a seven-fold greater rate in the first years of childhood than at the subsequent period of from 7 to 14 years, and between 14 and 21 years of age the rate of diminution yearly is only one-third of that which is found in the preceding septennial period.

536. *There is a progressive growth of the body in height and weight as the rate of the functions subsides.*

537. In reference to height Quetelet has shown that there is the greatest yearly development in the first year of life, but from the 5th to the 16th year it is very uniform year by year. The full height is attained in males about the 25th year, but it is found some years earlier in females.

538. Quetelet has also shown that from birth to puberty the male is heavier than the female, and attains his greatest weight at 40. The female after puberty does not gain weight proportionately during the period of child-bearing, and it is only at about 50 years of age that she attains her maximum weight.

539. *The teeth are usually developed at fixed periods of life.*

540. This condition may suffice, according to Mr. Saunders, to determine the age of the child with as much certainty as it is employed to ascertain the ages of animals. The following is derived from his researches.

541. The central incisors are developed at æt. 8 years; lateral, 9 years; the 1st bicuspid, 10 years;

2nd ditto, 11 years; canine, 12 to $12\frac{1}{2}$ years; second molars, $12\frac{1}{2}$ to 14.

542. The periods of both first and second dentition are attended with danger, and add much to the actual risk of infancy and childhood.

543. *There is a change of diet, so that starch and flesh partly or wholly supplant milk.*

544. We have shown that the amount of carbon supplied by each pint of milk is nearly equal to that contained in 4 ounces of starch or about 6 ounces of bread, but the quantity of nitrogen is twice as great as that which is contained in bread. Hence, in supplanting three pints of milk daily, there must be at least 18 ounces of bread if the carbon alone be considered, and 36 ounces if the nitrogen be required; and this is the quantity which has been shown to be necessary for adult life. If, therefore, the quantity of bread which is actually supplied to young children be intended to supplant the milk of infancy, it is manifest that the reduction of nutritive material in relation to the relative tone of the system is exceedingly great,—much too great to sustain the rate of growth which is then required. In order to meet this defect, meat is added by a large part of the community; and whilst its importance is doubtless very great, it is not unlikely that the habits of society have unduly estimated its value. In point of carbon, an ordinary sample of meat is equal, weight for weight, to bread; but it possesses $8\frac{3}{4}$ grains of nitrogen in each ounce, whilst the quantity in one ounce of bread is only $5\frac{3}{4}$ grains. Hence,

weight for weight, the addition of meat to a bread dietary causes an increased supply of nitrogen, but not to the extent which popular belief in the efficacy of meat warrants, and by no means to the amount which is found in cheese, in which substance there are 19½ grains of nitrogen in each ounce (note, p. 251).

545. These considerations show that if bread and meat be added to the quantity of milk, the nutritive amount of food may be greatly increased; but if milk, with its large amount of both nitrogen and carbon, be withheld, it would require a larger quantity of bread and meat to supply its place than it is the custom to give; and hence we would most earnestly urge the extreme value of an abundant supply of milk to all growing persons.

546. We feel assured that there is a popular error in reference to the true nutritive value of milk; for when recommending it to hospital patients, we are frequently met with the remark that they cannot afford it—thus assuming that it is a more expensive article of food than bread, with some small proportion of meat added. When milk is obtained at the country rate of charge, and the 4lb. loaf costs 8*d.*, the cost of the two substances is nearly equal if the nutritive elements in each be duly estimated, for it is probable that, on the average, 8 ounces of bread are equivalent to 1 pint of milk in nitrogen, and exceed it in carbon.

547. *The ordinary practice of vegetarians is not without reason.*

548. There is a class of men known as vegetarians

who affirm that they live well, and are in perfect health, without eating animal flesh. They do not, however, restrict themselves to vegetable diet, as their designation would imply, but cook their food with fats of various kinds, and take eggs and milk; their real restriction being that they do not eat the flesh of animals, to procure which the life of the animal must be taken. We are aware that this is a matter in which religious feeling is mixed up with a discussion on dietary, and, therefore, that in this, as in the Temperance movement, something more than the physical effect of food is brought into question; yet, regarding it in the latter aspect only, we cannot doubt but that there is reason on their side. It is quite certain that man in his prime estate did not eat the flesh of animals. It is also certain that a large section of every community very rarely eat flesh, and yet they labour well, and, as our agricultural labourers, are amongst the long-lived of mankind. In some countries, as in Spain and Sweden, scrofula and lepra appear chiefly amongst those who do not eat flesh; but this, in all probability, indicates a very meagre diet in other respects, and is not simply due to the deficiency of one kind of food. In the prisons of our country there is the greatest diversity in the amount of flesh supplied to the prisoners, so that in Middlesex and at Brecon 6 ounces of cooked meat, without bone, are allowed at dinner to those condemned to four months' imprisonment, whilst at Cardiff no meat is supplied, however long may be the duration of the

imprisonment. Such facts as these, embracing so great a multitude of people, must tend to show that flesh is not so essential to health as is commonly believed. We have also found, in an experience of three months, that a diet from which meat was altogether excluded was highly conducive to free mental labour, and produced a degree of calmness of system which was most agreeable, and suited to the duties of a quiet life, but there was a tameness of the animal spirits which would be thought to render a man less manly.

549. We also in medical practice find ill effects daily from eating too much animal food, and have proved that a limitation to 3 or 4 ounces of cooked meat in a middle-aged person was much more healthful than a larger supply. Then add to these facts the very varying composition of the different parts of the animal in reference to fat, albumen, juices, and membrane, so that whilst 2½ or 3 ounces of the back loin of beef would satisfy a moderate meat eater, it would require 6 or 8 ounces of an inferior part, as the neck of mutton, to produce the same effect.

550. Whilst, therefore, we do not commend the views of the vegetarian to universal adoption, we admit that they have much truth and reason on their side, and believe that the human system would be quite as well fed with much less meat if other kinds of animal produce were supplied. The evil of our poor is that they cannot obtain sufficient milk and eggs amongst animal food, and in the absence of

these do not take enough fat. We would urge the use of abundance of milk in the dietary of young people, and thus we feel assured, that whatever may be the other defects, they will not be seriously underfed.

551. *All the products of excretion are absolutely increased.*

552. It has been shown that the amount of food taken in very early life, when compared with the weight of the body, is far greater than is used in adult life, and, therefore, there is a gradual diminution of this relative amount as youth advances; but the total food, as well as the total excreta, increase year by year.

553. *Carbonic Acid.*—Thus, in reference to the products of respiration, Andral and Gavarret found the following results, so far as their experiments enabled them to infer the whole production of carbon during the day.

TABLE No. 37.

	Moderate Development.			Good Development.		
Æt. years .	8	12	14	16½	18	20
Carbon[1] (grains exhaled per hour) . .	67·	113·9	126·2	157·	169·4	166·3

[1] To find the amount of carbonic acid represented by the carbon, multiply the latter by 3·66; and to convert grains into grammes, multiply the former by 15·44.

554. Scharling, by another method of inquiry, found as follows :—

TABLE No. 38.

	Boys.			Girl.
Æt. years . .	$9\frac{3}{4}$	10	16	19
Carbon, grains per hour . . .	86	80	144	106

555. The results contained in the two preceding tables cannot be perfectly relied upon, since the carbonic acid excreted was collected only during short periods, and the quantities in the longer periods were inferred from those results, but so far they show that there is an absolute increase in the evolution of carbon with age. In Andral's cases, the increase was 11·8 grains per hour per year, from 8 to 12 years of age, 6·3 grains from 12 to 14 years of age, and 8 grains from $16\frac{1}{2}$ to 18 years of age. In Scharling's experiments, the increase was 10·0 grains from 10 to 16 years of age.

556. Andral and Gavarret do not give us the data from which to calculate the influence of weight, but in the table we have classified those which varied in development.

557. Scharling has recorded the weight of his subjects, and it appears that the proportion of carbon excreted to each lb. weight of the body decreases with age, as follows :—

TABLE No. 39.

	Boys.			Girl.
Æt. years .	$9\frac{3}{4}$	10	16	19
Grains of Carbon to each lb. weight of body . .	46·6	48·3	30·	22·8

558. The diminution between 10 and 16 years of age was 3·05 grains of carbon per hour per year, when compared with the amount of carbon as compared with the weight of the body.

559. Sex was shown in all the experiments to have an influence, but the difference is commonly believed to resolve itself into the question of the weight and exertion of the body. Andral and Gavarret, however, inferred that the evolution of carbon attained its maximum at the commencement of menstruation, and experienced no further increase until after the cessation of that function (except during pregnancy); but it is evident that there were causes of variation omitted in this calculation, and that further experiments are still necessary before the results obtained can be relied upon for physiological reasoning.

560. *Urea.*—The amount of urea excreted varies with age, as is shown in Table No. 40.

561. These analyses vary somewhat, but all agree in proving that the amount of urea excreted absosolutely increases with age, but at the same time it decreases with age when regarded relatively to the weight of the body. Thus, whilst 5, 6, or 7 grains to

TABLE No. 40.

	Scherer.		Rummel.				Bischoff.		
Age in years and sex.	3½ Girl.	7 Boy.	3 Boy.	4 Boy.	5 Girl.	18 Youth.	3 Boy.	16 Youth.	18 Girl.
Grains of Urea in 24 hours	200	282	209·4	240·5	281·2	563·4	220·	306·4	311·5
Grains of Urea to 1 lb. weight of body	5·6	5·7	7·	7·5	7·6	4·3	6·26	2·8	2·14

each lb. weight of the body are emitted daily at 3, 4, or 5 years of age, the quantity is reduced to 2, 3, or 4 grains at 16 and 18 years of age. When this comparison is made between extreme ages, it is found that the urea excreted in childhood relatively to the weight of the body is three times greater than that excreted in old age.

562. *Urea is a mixed product of the destruction of tissue and the conversion of food.*

563. The true value which should be attached to the production of urea is yet unknown, for one party affirms that it is a measure of the waste of tissue, whilst another believes it to be chiefly due to food. There is no question in physiological chemistry on which so many observers are engaged as upon this, and it is probably destined to overturn many of the theoretical views of nutrition which have of late years occupied our text-books. The directions of inquiry seem at

present to be three:—1st, the waste of muscular and other tissues; 2nd, the assimilation of food; and 3rd, the excretion of food in that part which is not used in the support of the system; and we will in a few words point out a few facts for reflection.

564. From various sets of inquiries in which we have been engaged we find:—

1. When the tread-wheel is worked for a short period, say $1\frac{1}{2}$ hour, in the absence of food, there is no increase in the *elimination* of urea during that period.
2. When the tread-wheel is worked with ordinary food, the increase of urea is not more than 5 per cent. over the quantity which is eliminated with very light work, and with the same food. Hence the direct effects of violent exertion in the production and elimination of urea are not very great under any circumstances.
3. When two different dietaries are provided varying in nitrogen, but the exertion always remaining the same, there is the greatest excretion of urea with the diet richest in nitrogen. After an unusual dinner, or after a public dinner, there is a larger excretion of urea. In flesh-feeding animals the nitrogen in the urea represents the nitrogen in the food.
4. When in the absence of food an unusual quantity of water is taken alone, there is an elimination of two or three times the amount

of urea that would have occurred if no water had been drunk, and much more than if the ordinary food had been taken.

565. From such facts there is reason to believe, 1st, that with sufficient food, the product of muscular waste cannot be dissociated from that of the transformation of food, and that the urea is chiefly derived from the nitrogen contained in the food after it has fulfilled its duty as an excitant of vital action; 2nd, that excess of nitrogenous food passes off as urea; 3rd, that urea must exist largely in the blood or in the extra-vascular fluids, either in its perfect state or in a state ready for the final transformation, and can be readily washed out of it.

566. Hence it is quite open to question, if the necessity of the system for nitrogen be chiefly to supply a waste of tissue proceeding from exertion (and this is the more questionable that a large minimum quantity at all times leaves the body as urea in the state of perfect rest), and if it be not rather necessary, as we have shown in reference to carbonic acid, for the purpose of promoting the assimilation of food. It is evident that there cannot be any increase of urea from muscular exertion unless the weight of the muscle be lessened, since the supply of nitrogen will run *pari passu* with the excretion of it, and the total quantity to be emitted from the body will remain the same.

567. It is worthy of the deepest consideration, that whilst urea is said to be the product of waste of tissue,

and yet is not emitted in any degree in proportion to the exertion made, carbonic acid, which is said to be the product of the conversion of the hydro-carbons, is influenced in a marked degree by the least amount of exertion, and increases *pari passu* with increase of exertion. This, surely, rather points to the connection of the production of carbonic acid from muscular force, and that as a direct act, as well as from its influence over the transformation of food.

568. Hence we must not infer that there is a progressive increase in the waste of the body as age advances, because during the period under discussion there is an increased emission of urea, but rather that more food is taken and perhaps taken in excess. The diminution in the excretion of urea in proportion to the weight of the body, is evidence that a part of the nitrogen becomes fixed in the tissues during the period of growth.

569. *The protection against dangers from without increases as the child advances from infancy towards adult life, by the diminution of the action of the skin, and increase of exertion and intelligence; but this may be prevented by injudicious management.*

570. This may be inferred from the remarks made under this head in infancy (514), for the conditions in the latter, which led to the danger, are now in great part removed. The skin has become less soft and vascular, and has acquired a thicker epidermis, so that it is less sensitive, and is less active in the dispersion of heat. This varies, doubtless, with the care

which has been taken during infancy; but it is worthy of note that those children which are freely exposed to the weather, and yet live through it, acquire the new condition of the skin much more early and effectually. The hardiness of the Highland child is attributed, with justice, to its exposure to all weathers; and although this is a plan of treatment under which many succumb, it is of inestimable advantage to those who survive.

571. Those, on the other hand, who have been tenderly reared, and have been accustomed to a warm temperature and much clothing, retain the sensitive and active state of the skin, which is so prominent a danger in infancy, and which will attend them in future life. We would affirm that a delicate, thin, soft, and perspiring skin is the most dangerous acquisition of a child, and that although it looks beautiful, the child would be infinitely better if it could be exchanged for one rougher and drier, and less easily induced to perspire. There can be no doubt that a skin so sensitive and active, in those who approach adult life, is the most common cause of pulmonary and scrofulous diseases, and it induces these conditions by not allowing a sufficient amount of nutriment to remain in the body, for the too great dispersion of heat also promotes its destruction and lessens the activity of the assimilative process. Thus there is a direct tendency to induce defective nutrition, and with it is commonly conjoined defective circulation and lowered vital action, as is seen in the cold hands and feet, the defective appetite,

and the defective force of the heart's action. Unless the temperature of the surface be well maintained, in such cases, by clothing and exertion, there can neither be prevention nor cure of disease. Such persons, moreover, are especially liable to "take cold," and by that means to call into action the mischief which is ever slumbering in lungs to which the blood is preternaturally directed; and hence, both in disposing to and provoking disease, the state of the skin to which we have referred is most efficient.

572. But after infant life the child is able to express its own wants, and by its own acts, as well as by the aid of those who take care of it, it is protected from danger and removed from any imminent but temporary cause of evil. The natural disposition of childhood to exertion is also most favourable to health, both by determining the blood to the skin, and by promoting a due amount of transformation of food. In children in whom there is a disposition to accumulate fat, this cannot be too much cherished, but in those of spare habit it should be kept within moderate bounds.

573. Thus upon the whole the danger from without should naturally lessen as infancy passes into childhood and childhood into adult life, when there is both due exposure and due precaution.

574. But we cannot pass over this part of the subject without referring to the want of precaution which, with recent improvement, is still too often manifested in the early years of womanhood in reference to

clothing. The thin shoes worn by them, the open nature of their dresses, the exposure of the upper part of the chest, and of the arms, all prove how much more the habits of society expose women than men to dangers from without. It is true that as a rule women are less exposed than men to the full influence of the weather, but by so much are they rendered less hardy (or more sensitive) by which to resist the effects of exposure when it occurs. They are, however, exposed to the most sudden vicissitudes of temperature, and in association with conditions which directly render them most sensitive to the effects of cold, and in this condition they are almost always insufficiently protected by due clothing. A state of profuse perspiration in the dance is soon followed by a cold shudder in the hall, and this by the chest disease, which carries so many of our fairest maidens to the tomb. It is far too common to allow the feet, and other parts of the body, to remain cold, and to permit defective appetite and lessened vital actions.

575. *The dangers from within are more numerous than at any other period of life.*

576. These are chiefly associated with dentition and defective nutrition.

577. *Dentition is not an immediate cause of tuberculisation.*

578. The dangers of dentition have been already referred to in connection with infancy, and shown to be associated with the extreme sensibility of system

which then exists. Those of childhood have been commonly connected with tubercle, but if they have truly any such influence it can only be as associated with the other conditions of system in which tubercular deposits in the lungs are liable to occur. It does not appear to us that this can be more than an exciting cause, whilst the predisposing and, indeed, the essential cause is associated with nutrition. We do not find that a child of healthy and vigorous system, and receiving abundant nourishment, assumes tubercular disease at the period of dentition; but in reference to the ill-fed, and those of feeble organisation, there is no difficulty in seeing abundant opportunity for the origination of tubercular diseases in the long period extending from the 8th to the 14th year (the period of the second dentition), quite apart from the dentition which is then proceeding. We doubt much if dentition *per se* induces the tendency above mentioned.

579. *Proper food cannot be too abundantly eaten.*

580. It must be recollected that during the whole period when growth is proceeding, there should be an excess of nutriment supplied, and so great is this requirement that it is scarcely possible to find a condition occurring in youth which is fairly attributable to mere excess of proper food. The disorders of the bowels, and the chylopœtic viscera, which are not uncommon, are due to errors in diet, by which improper food is supplied and may remain in excess, and are not due to excess of simple and proper

food. This is a point upon which we desire to lay great stress, and it is one which village mothers commonly understand much better than mothers born and living in our large towns. We unhesitatingly advise that no limit should be placed to the quantity of suitable nutriment which a growing youth is disposed to take, for whilst it is scarcely possible to do harm in that direction, it is certain that much evil results from the contrary conduct.

581. *Alcohols are not true foods, and are not necessary from childhood to adult life, except as remedial agents.*

582. This is a convenient point at which to discuss the value of alcoholic liquors in the dietary of youths and young men, for if we must admit them as necessary parts of the dietary, we fear we must contradict the assertion just made, and admit that it is possible to take food in excess.

583. It is proper to look at this matter under two aspects: 1st, are alcoholic liquors necessary? 2nd, are they injurious?

584. We have given a prolonged attention to the physiological action of these substances and have arrived at the firm conviction that in health and under ordinary conditions they are not necessary. Let us look at their action.

585. Alcohol[1] certainly in any dose lessens mus-

[1] Papers in the "Journal of the Society of Arts," Jan. 18, 1861; "The Transactions of the Society for the Promotion of Social Science," 1860; "London Medical Review," April, 1861; "The Lancet," Feb. & March, 1861; "Transactions of Medical Society of London," 1861.

cular power, muscular action, and nervous sensibility, as also the action of the skin, the salivary glands, and the mucous membranes, and in several of these ways disturbs the circulation and the due balance of the system. There is no part of its action in which it can be regarded as a true food, and having arrived at the conviction that it is not a food, and that it passes out of the system without undergoing any, or at least, a final transformation, we are glad to find that M. Lallemand and his colleagues have recently proved that alcohol, as such, passes from the lungs, the kidneys, and the skin, for some hours after a moderate quantity of it has been taken. They have not succeeded in collecting the alcohol in any quantity, much less in the quantity which had been drunk, but they have proved its presence by its reaction upon bichromate of potass, dissolved in sulphuric acid, and have found it unchanged in the tissues for many hours after it has been taken. This then is the missing link (although it is not quite perfect) by the aid of which we may disprove the chemico-theoretical theories based upon its composition, and show that it is a powerful disturber of the whole organism whilst present, and like a poison it is, as it ought to be, ejected.

586. Hence, therefore, alcohol, and all spirituous liquors which chiefly consist of alcohol can in no sense be regarded as necessary to the system. They have, however, two principal actions by which under exceptional conditions they may be very useful, viz., the power to increase the force of the heart's

action, and to lessen or prevent perspiration from the skin. In cases of debility in which the tone of the heart is implicated—in periods of exhaustion, as after excessive labour, exposure to great heat, excessive fear, or other mental excitement—the first may be very valuable; and in instances in which perspiration is too profuse or in which the ordinary waste of heat by the skin should be greatly lessened, or during temporary exposure to cold and in the absence of food the latter may be invaluable. If on the other hand the action of the skin be arrested when it ought to be most active, as when the body is exposed to a much greater degree of heat than its own standard temperature, what is so certain as that the body will become too heated to permit life to continue, whilst the internal organs will become congested and sunstroke occur?

587. All these conditions are states of disease, and in the more important ones the greatest consideration should be given before alcohols are administered.

588. The quantity of the various alcoholic liquors which men commonly drink seems to have been graduated to the common effect of disturbing the consciousness, for it is interesting to note that if two ounces of spirit be the common lowland dose in spirit and water, there will be the same quantity of alcohol in 1 to 1½ pint of good ale, and in about ½ to ¾ pint of wine.

589. We wish also particularly to call attention to the fact that there are other important substances besides alcohol in spirits, wines, and beers, and that they modify the effect of the alcohol. We found that

brandy and gin always depressed the exhalation of carbonic acid, while rum as commonly increased it, and whiskey differed with different specimens, but the effect in either direction was not great.[1] Wines are chiefly valued for their aromas, which consist of unknown volatile oils and ethers, and as they become older they gain aroma and lose alcohol. This aroma is a most valuable agent in the wine, since its inhalation was alone sufficient to lessen the vital changes. Hence, old wines certainly have a part to play different from that of spirits.

590. Alcohols are said to lessen the excretion of urea and since they *disturb* every vital function (rather than act in any definite manner), and lessen the excretion of water, it is highly probable that this is the case. But we wish to express our conviction that this is only a temporary action, and that if the system should remain fitted for the healthful discharge of its duties, this effect will pass away after a few days. This we have proved in our experiments in prisons.

591. Beers contain sugar, gluten, and other nitrogenous compounds, besides alcohol, and we have shown that by them they have the property of promoting the transformation of food. Hence, the question is not

[1] In reference to the actual influence of alcohols over the elimination of carbonic acid, it should be well understood that the extent of this action is always small, viz., to $\frac{1}{2}$ or $\frac{3}{4}$ of a grain of carbonic acid per minute, whether of increase or decrease. Hence this is not the principal action of alcohol, and it bears no relation to the power which true foods, and particularly sugars, have over the respiratory function.

so much whether beers contain nutriment as to whether they are capable of improving nutrition, and this power must be conceded to them.

592. Are beers then necessary in the dietary of young men? We answer "No," if there be a healthy system and a healthy appetite. The powers of the system are then alone sufficient to transform suitable food and require no such extraneous aid, but if there should be an excess of starchy food taken, and a deficiency of nitrogenous food, then it is very probable that a little very good ale would promote its transformation. This is, however, again an error in, rather than an excess of food, and is allied to disease. Hence, on the whole we venture to say, that neither spirits, wines, nor beers are *necessary* in any scheme of dietary for growth in health.

593. But are alcohols injurious? It appears to us that this question loses its importance in the eyes of a rational man, for in preparing a scheme of dietary or in nourishing youth, the question is not what is not injurious, but what is beneficial or necessary. It cannot be denied that the very occasional use of a glass of wine or a little beer leaves no evidence of any ill effect, and we may venture to say that in a healthy system they do not effect injury. Moreover the light ales and the bitter beers of the day are nearly valueless for all good purposes, and not very potent for any evil—they are expensive delusions.

594. If alcohol, however, in any of its forms be taken so as to affect the tonicity of the muscles and

to disturb consciousness, it seems impossible that it should not be injurious in some degree, and although by the benign power of the system it may be removed, it cannot have left anything but an unhealthy tendency in its place.

595. The system has great power of adapting itself to adverse influences, and a greater power of recovering from evil effects, and hence a man may indulge his tastes for a poison with a degree of impunity, but we can have no doubt that alcohol in any quantity acts contrary to the well-being of the system, unless it be taken under exceptional circumstances. We therefore advise that alcohol be excluded from the ordinary dietaries at the period under discussion, and may consequently renew our affirmation, that an unlimited supply of suitable food should be afforded to our youth.

596. *The greatest danger arises from defective nutrition.*

597. We now turn to the most important part of this subject, and shall proceed to show the periods when defective nutrition seems to be the most injurious.

598. There are three periods to which attention must be given, viz., those of childhood, puberty, and adolescence.

599. The evils of defective nutrition in childhood are deficient rate of growth and impoverishment of the system. We have shown that from infancy to seven years of age (and perhaps it might have been further extended) there is a very large consumption

of food and elimination of the products of vital action in relation to the weight of the body, and we regard this as the normal state of the system at that period. If therefore the supply of food should be defective when it ought to be in great excess, it must result that the growth of the body (or the required excess of vital action) will be proportionately impeded, and as the period of growth is limited to a few years of life, the loss of one or more years in the due progress of this development must be irremediable. There can be no doubt that whilst there are limits to the rate of growth affixed to the constitution of each individual, it is true that it will *cœteris paribus* proceed in proportion to the amount of transformation of food, and therefore in proportion to the quantity and quality of food supplied, and the activity of the digestive powers.

600. Hence the first evil which follows defective nutrition in childhood is the diminution of the rate of increase or growth, and the second and more advanced evil is the impoverishment of the system by not meeting the waste with a due supply. There is also a close intimacy between these two results, and it will be but seldom possible to show practically that the one proceeds without dragging the other at its heels, and hence the resulting condition may be both one of stunted development and diseased vital processes. The constitutional character of the future man or woman will as certainly be determined at this period as that the direction towards it was given before and

at birth—a condition possibly not one of evident disease, but one always tending thereto.

601. *Puberty.*—The period of puberty is associated with two classes of evils, viz., excessive development of the cerebro-spinal axis and defective growth of organs of organic life.

602. *Excessive development.*—About the period now under consideration, it is common to notice that the rate of growth has suddenly increased to a degree which has attracted general attention. This may or may not be associated with the development of the sexual instincts, and if it should be, it is probable that there is no true causal connexion between them.

603. In this condition of unusually rapid development there must have been an unusual expenditure of vital force and of any previously accumulated products of nutrition, so that there is an urgent necessity for a rapid increase in the supply and conversion of food. But it very frequently happens that at this very period of urgent need the appetite fails, and all the vital powers are enfeebled, not as the result of the absence of the accustomed supply of food (however much that may also exist), but as the result of the previous expenditure of the store of food. This state is supposed to be accounted for by the statement that the vital force has been expended and almost exhausted in the formative act, but that helps us but little to show why the accumulative action had not kept pace with the formative, and we are left with the

general observation that whilst the vital force is commonly equally distributed over every vital act, there are occasions in which it may exhaust itself by throwing the chief part of its powers in one direction only. It will be observed that these are speculations of very doubtful utility, and before they can be accepted we must have more minute knowledge of the vital powers and their modes of action. The point, however, to which we especially desire to ask attention is the imperative necessity of meeting this probable defect by a rapid and great increase in the supply of food and in the power of transformation. At this period, as in infancy, it is essential that the supply should be highly azotised, not only that nitrogenous materials may be supplied out of which the growing tissues may be formed, but that the assimilation of the hydrocarbons may be well and rapidly effected.

604. We have already intimated that at this period the temperature of the body is especially liable to be in defect. The cold, soft, thick skin, and the feeble power of the heart, the listless mind, the inactive body, and the cold feet, testify to this fact, and add greatly to the evil tendencies of the period, and if at any time alcohols may be properly given as a part of the dietary, no more suitable condition for their use could be found.

605. The kind of danger to which this period of life is subject is not constitutional and remote so much as local and near. Old age is established in childhood, but manhood depends upon puberty.

606. *Defective development of the lungs.*—The second condition, or that of disproportionate growth, refers to the excess of development of the parts of the cerebro-spinal axis over that of the organs of organic life, and more particularly of the lungs. It is impossible to notice the configuration of the body of a rapidly growing girl, who has just passed the period of puberty, without feeling assured that the lungs do not expand in a ratio equal to that of the development of the body. The body is tall, but the thorax is narrow and flat, and the apices of the lungs approach very closely to each other. The width across the shoulders is small, and very disproportionate to the height of the body; and, as a whole, the reparative organs seem out of proportion to the body which has to be sustained.

607. Hence arises the necessity for that deep voluntary distension of the lungs which we have elsewhere commended, and which mechanically tends to the more complete development of the lungs and their containing cavity. Posturing of the body, although very valuable, but inadequately meets this requirement; and violent exertion, although most desirable, is almost impossible from the sense of inadequate respiration, and from the increased waste which would be occasioned. The proper course, no doubt, is to adopt all these measures, and to conjoin with them the improved nutrition which has just been advised.

608. The insufficient development of the inspiratory muscles is necessarily associated with this condition, and we are disposed to attach more importance to this

subject than has hitherto been conceded to it. It is impossible to avoid seeing the close connection between all the three conditions; viz., defective general nutrition, imperfect development of the lungs and the inspiratory muscles, and the occurrence of consumption; and not to believe that, however other causes may act, these act immediately by the incomplete expansion and insufficient vital activity of the respiratory organs. If to this we conjoin the tendency to low vitality associated with excessive loss of heat, and perhaps also the loss which accrues to the system from the catamenial discharge, we feel that no other reasons for the occurrence of phthisis at this period of life need to be adduced.

609. This, then, is the period when the seeds are sown which bear fatal fruit in so large a portion of our race before they attain to the period when the body has reached its perfection, and its tendencies are no longer in the direction of exhaustion. We may be assured that sufficient attention is not paid to our youth at this period of life with a view to prevent the dangers to which they are thus especially prone; and we too commonly rest content with a general belief in the danger and a general caution, whilst the period arrives when the evil is beyond remedy.

610. *The dangers of adolescence are those of puberty, but the former are chronic and prolonged, whilst the latter are acute and short.*

611. At the period of adolescence, there is great liability to excess of formation over nutrition.

612. *Urea.*—We now deduce an argument from the amount of urea and carbonic acid eliminated, which has a different bearing from those already given. In adolescence we find the proportion to the weight of the body greatly reduced, and lowered to a point below which it will not pass for many years to come. This is proved by the tables on pages 271 and 305, which show that two to three grains of urea to each lb. weight of the body is the whole excretion at 16 to 18 years of age, whilst at 30 and 35 years of age the proportion will be scarcely less. But what is the significance of this fact? Is it the benign one that there is less waste of tissue, and thereby an increasing growth of body?

613. The discussion of this point involves the question of the origin of urea, to which we have already drawn attention. Whatever may be the source or sources of urea, it is quite certain that urea bears a relation to excess of food, and hence any considerable diminution of it must certainly imply a diminution in the amount of food taken. This argument cannot be carried beyond a certain limit, because if there should be an entire absence of food, a large amount of urea would still be eliminated, and this must have been derived from the stored-up material of the body; but in the case now under discussion, we may affirm that the excess of food over the amount required to meet the daily waste which was seen in childhood has disappeared, and there is a serious possibility of its falling below the requirements of the

growing system. If, therefore, the growth of the body have ceased at the period in question, there will still be a parity between the wants of the body and the supply of food, and no evil may result; but as this is not usually the case, and yet the proportionate evolution of urea is almost as small as is found at a later period of life, when growth has ceased, we must beware of the danger of defective nutrition which is ever present.

614. The danger will manifestly be the greatest in those who are still growing rapidly, and to those who having grown rapidly in previous years were unable to maintain nutrition in due proportion, and thence fell into defect. In all cases, but especially in these, we would urge the duty of maintaining the assimilation of food in the highest possible state of perfection, and to regard with the greatest suspicion any long-continued defect in that process.

615. *Mineral matter.*—We have not in these various discussions entered at any length into the kind of dietary which is the most fitted for the period of increase, but we have intimated how great is the importance of nitrogen in promoting rapid assimilation of food, and we now add a few observations on the importance of supplying an abundance of mineral ingredients, as salts of soda, potash, and lime, for the due consolidation of the bones and the perfection of the other textures of the body. In reference to chloride of sodium we may remark that it is believed to promote the solution of the protein compounds, as

albumen and casein, and perhaps also aids in the excretion of urea, and therefore is undoubtedly as useful as the general desire for it would seem to indicate; but we must at the same time quote the results of M. Fernet,[1] that excess of chloride of sodium in the blood lessens the capability of that fluid to absorb all gases (and, therefore, carbonic acid), and hence must limit the transformation of food. This then is a matter of more serious importance than a mere relish for an article of diet. It may well be questioned how far it is wise in prison dietary to allow so large a quantity as one ounce daily to each prisoner (besides that which is used in the cooked food), and it is a matter of gratulation that there is an outlet for it in the urine. We have constantly found from 1 to 1½ ounces of salt per day in the urine, when the full quantity of salt was allowed in the food; whilst by withholding three-quarters of an ounce of salt daily from the food, the quantity found in the urine was lessened by precisely the same amount.

ADULT LIFE.

616. We have now arrived at a consideration of the period of life when the vital actions approach the nearest to an equilibrium—a state in which the waste of the system may be, and ordinarily is, exactly counterpoised by the supply of food. This period embraces a very large proportion of human life, since commencing at 20 to 30 years of age it may extend to

[1] Thèse, Paris, 1838.

between 40 and 50 years of age, and within it may be comprised nearly all that men do either physically or mentally by which they benefit themselves or influence their connections or the world. It is the period when the human system attains to its maximum degree of perfection, affords the highest degree of enjoyment, and is naturally exposed to a minimum of ills.

617. It is not, however, strictly true, that the vital actions do not continue to increase, for some parts of the body are still imperfect, and it is not until near the 30th year that the epiphyses, transverse and spinous processes of the vertebræ are complete, and the bone is perfected; the os coccygis formed into a single piece; the occipital bone united with the sphenoid; the third piece of the sternum united to the fourth; and the union of the epiphyses to the ribs, the scapula, clavicle, the os innominatum, the tibia, and fibula. The union of the second with the third piece of the sternum does not occur until even 10 years later, and in old age only is the sternum completed, and the os coccygis consolidated with the sacrum. These circumstances do not however materially affect the organism, since they are associated chiefly with the deposition of mineral matter, and are strictly localised.

618. *The rate of the functions continues to decline.*

619. The rate of pulsation and respiration progressively declines, but only by slow degrees, so that we find it in the inquiries which occupied the whole day, and already recorded on pages 7 and 30, as follows:—

620. In one series (12) embracing every hour of the 24 hours, and for 72 consecutive hours, in the lying posture, the pulsation was as follows :—

TABLE No. 41,

SHOWING THE TOTAL AVERAGE RATE OF PULSATION AND RESPIRATION AT VARIOUS AGES.

	Female.	Female.	Female.	Male.	Female.
Æt.	6	8	33	36	39
Pulsation, per minute.	94·2	80·	73·4	72·2	61·
Respiration ,,	20·6	20·8	18·3	17·8	17·8

621. In another series (48), continued only through the 18 hours of the daylight day, the reverse progression in pulsation was observed in the sitting posture.

TABLE No. 42.

	Æt. 26.	Æt. 39.	Æt. 48.
Pulsation, per minute . .	71·3	83·7	85·7
Respiration ,, . .	15·4	15·2	14·45

622. The ratio of these two functions also declines with age, as we found in the inquiry into respiration which occupied 18 consecutive hours (48). With a series of four persons æt. 26, 33, 39, and 48 years, the proportion was the greatest in the youngest, and declined progressively to the oldest, and was 1 respiration to 4·63, 5, 5·25 and 5·72 pulsations in their order. But in another inquiry which occupied

72 consecutive hours (14), and was made upon both children and adults, the progress was not so uniform, but was as follows:—

TABLE No. 43.

Ratio of Respiration to Pulsation at various Ages.

Æt. years.	6	8	33	36	39
Ratio.	$\frac{1}{4·5}$	$\frac{1}{3·9}$	$\frac{1}{4}$	$\frac{1}{4·1}$	$\frac{1}{3·4}$

623. The significance of this fact is the indication which it affords of the gradual but progressive diminution of the chemico-vital changes, for it would seem to follow that the more frequent the inspiration in relation to the frequency of the exposure of the blood to the action of the air, the greater will be the amount of vital action, and it is highly probable that such is the fact.

624. *The vital capacity of the lungs varies less with age than height.*

625. The amount of air which the lungs are capable of containing does not seem to vary greatly during this period of life, as shown by Dr. Hutchinson. The returns which he obtained were so variable that it was impossible for him to educe a law, but, as a general expression, he found that the vital capacity increased up to 35 years of age, and thenceforward decreased, but he qualifies this statement by advising that no allowance be made for diminution until 55 years of age. He found that the vital capacity is liable to

be influenced by other conditions, as for example weight, but more particularly by height, in which it increased 8 cubic inches with every increasing inch of height between 5 & 6 feet, as shown in the following table extracted from his work on the Spirometer.

TABLE No. 44.

VITAL CAPACITY (STANDING) IN 4,400 MALES.

HEIGHT.	AGE.			Minimum, 16 per cent. below the mean.
	15 to 55	55 to 65	65 to 75	
Feet. Feet. 5 0 to 5 1	174	163	161	146
5 1 ,, 5 2	182	173	168	153
5 2 ,, 5 3	190	181	175	160
5 3 ,, 5 4	198	188	182	166
5 4 ,, 5 5	206	196	190	173
5 5 ,, 5 6	214	203	197	180
5 6 ,, 5 7	222	211	204	187
5 7 ,, 5 8	230	219	212	193
5 8 ,, 5 9	238	226	219	200
5 9 ,, 5 10	246	234	226	207
5 10 ,, 5 11	254	242	234	213
5 11 ,, 6 0	262	249	241	220

As there are therefore so many factors employed in determining the amount of vital capacity, it is most difficult to eliminate the real effect of age, and it is to be regretted that by a determination of the proportion of air inspired to each inch of height at the same age, a

more complete attempt was not made to obtain this important information.

626. *The amount of carbon expired varies with weight, age, and labour.*

627. The amount of carbon[1] evolved by the lungs in the 24 hours has been variously estimated at from 5·45 to 13·9 ounces avoirdupois, but in these inquiries the carbonic acid was collected in periods not longer than from a few minutes to about 1 hour. In 1858 we collected on two occasions (48) the whole of the carbonic acid which was excreted during the 18 hours of the daylight day, and at various periods during the night, and found that the quantity per day varied in the sitting posture and in perfect rest as follows; and on two other occasions we determined the amount evolved at the commencement of each hour from 6 A.M. to 12 P.M. by four healthy men.

TABLE No. 45,

SHOWING THE DAILY AMOUNT OF CARBON EVOLVED AT DIFFERENT AGES.

Æt. years .	26	33	39	48
Carbon oz. .	6·54	5·6	7·85	6·735

628. Thus it did not follow the order of age.

629. In reference to the relation of the carbon to the weight of the body there is also a want of uniformity, but when this relation is conjoined with that

[1] To find the amount of carbonic acid, multiply the weight of carbon by 3·66.

of age it is singular to notice how close is the connexion, as shown by the following figures :—

TABLE No. 46,

SHOWING THE WEIGHT OF EXPIRED CARBON IN OUNCES TO EACH POUND WEIGHT OF BODY.

Æt. 48	Æt. 39	Æt. 33
oz. grs. ·039 (17·07)	oz. grs. ·04 (17·51)	oz. grs. ·0411 (17·99)

630. Hence the proportion of carbon expired daily to each lb. weight of the body decreases with age, and whilst it is 17 to 18 grains per day for each lb. weight in the whole of middle life, it diminishes by about $\frac{1}{3}$ of a grain for each 5 years of age.

631. During exertion it was found that walking at 2 miles per hour, and carrying 7 lbs., the quantity of carbon evolved was 6·63 grains, and at 3 miles per hour 9·47 grains per minute,—quantities equal to 1·85 and 2·64 times that of quietude, whilst on the tread-wheel when lifting 196 lbs. through 1920 feet per hour, or 650 tons through 1 foot per day, it was 15·76 grains per minute, and these quantities when estimated for each lb. weight of the body become ·0338 grains, ·0483 grains, and ·08 grains per minute, or 48·67, 69·55, and 115·2 grains per day respectively.

632. When therefore an estimation is made of the labour which the various classes of the community make daily, we find the actual quantities of carbon expired in the 24 hours to be as follows :—

	Oz.
In rest, with $2\frac{1}{2}$ hours' standing	7·144
Non-laborious Class.—With 3 hours' walking at 2 miles, and 1 hour at 3 miles per hour, in addition to the $2\frac{1}{2}$ hours' standing	9·11
Laborious Class.—Three times the above addition .	11·7

633. On the average of the whole the quantity is 9.18 ounces daily, and as the average weight was 160 lbs., the quantity of carbon expired per day to each lb. weight of body is, at rest, $19\frac{1}{2}$ grains, as an unoccupied man 25 grains, as a hard-working man $30\frac{3}{4}$ grains, and on the average of the whole 25 grains per day.

634. *The quantity of air inspired has a relation to the carbonic acid expired.*

635. This is a different question from that of the vital capacity of the chest, to which we have already alluded (625), for it indicates the amount which is actually inspired, and not that which the lungs are capable of receiving.

636. There is a relation of so close a character between the quantity of air inspired and that of the carbonic acid expired, that any variation of the one under the same conditions will be accompanied by a corresponding variation in the other. In a state of rest, the proportion in the experiments before referred to was 1 grain of carbonic acid to 58·5 cubic inches, 58·0 cubic inches, 54·1 cubic inches, and 54 cubic inches of air inspired in the different persons, or a total average of 1 grain to 56·3 cubic inches, but during exertion the proportion was increased to 1

grain in 44·1 cubic inches and 39·7 cubic inches when walking, at 2 and 3 miles per hour respectively.

637. When, therefore, it is desired to represent the amount of chemical change connected with the respiration by the amount of air inspired, the result will only be an approximation, and when the conditions are very diverse, there will be more chemical change represented by the quantity of air accompanying considerable exertion. As there have not been any other extended experiments in reference to the effect of exertion over the elimination of carbonic acid, we venture to insert a series of results obtained by us in reference to the quantity of air inspired, and we think that they have both interest and value.

638. The following table shows a comparison of the effects of numerous modes of exertion with each other. The state of rest in the lying posture is regarded as unity.

TABLE No. 47.

Thus the effect in the lying posture being . .	1·
That of the sitting posture is	1·18
Reading aloud and singing, each	1·26
The standing posture	1·33
Railway travelling in the 1st class	1·40
,, ,, 2nd class	1·5
,, ,, upon the engine, at 20 to 30 miles per hour	1·52
,, ,, ,, 50 to 60 ,, .	1·55
,, ,, in the 3rd class	1·58
,, ,, upon the engine (average of all speeds)	1·58
,, ,, ,, at 40 to 50 miles	1·61
,, ,, ,, 30 to 40 ,, .	1·64

Walking in the sea	1·65
,, on land at 1 mile per hour	1·9

All the above have an influence exceeding, but not double, of that in the lying posture.

Riding on horseback at the walking pace	2·2
Walking at 2 miles per hour	2·76

These have between two and three times the influence of the lying posture.

Riding on horseback at the cantering pace	3·16
Walking at 3 miles per hour	3·0
Do. do.	3·22
Rowing	3·33
Descending steps at 640 yards per hour	3·43
Walking at 3 miles per hour, and carrying 34 lbs.	3·5
,, ,, ,, 62 lbs.	3·84

These have an influence from three to four times greater than that of the lying posture.

Riding on horseback at the trotting pace	4·05
Swimming	4·33
Ascending steps at 640 yards per hour	4·4
Walking at 3 miles per hour, and carrying 118 lbs.	4·75
,, 4 miles per hour	5·0

These have an influence from four to five times that of the lying posture.

The tread-wheel	5·5
Running at 6 miles per hour	7·0

639. Thus it is possible that the quantity of air which we breathe may be increased at least sevenfold for a short period.

640. The relation which one influence bears to another may be readily determined by noting their relative quantities, as also what duration of one

influence would be equal in effect to a different duration of another. Thus, by way of example, the influence over respiration of riding on horseback at the walking pace is a little greater than walking at 1 mile per hour—that of cantering on a rough horse is equal to walking at three miles per hour, and carrying 20 lbs.; that of descending steps at 640 yards per hour is equal to walking at 3 miles per hour, and carrying 34 lbs.; whilst that of ascending steps at 640 yards per hour is a little greater than that of swimming, and greater than that of trotting on horseback. Swimming is more than equal to the trotting pace on horseback, whilst rowing is more than equal to the cantering pace.

641. In reference to the carrying of weight there was an addition of 8 cubic inches for every lb. weight carried above that of the body.

642. *The depth of inspiration does not vary as the age.*

643. The quantity of air (52) which was received at each inspiration during rest was 30 cubic inches, æt. 26; 30·9 cubic inches, æt. 33; 33·6 cubic inches, æt. 48; and 39·5 cubic inches, æt. 39, in the various persons, and 33·6 cubic inches on the whole average, but with exertion it was increased in him who, at rest, inspired 39·5 cubic inches to 52 cubic inches, 60 cubic inches, 75 cubic inches, and 91 cubic inches when walking at 1, 2, 3 and 4 miles per hour, whilst it was 100 cubic inches when working the tread-wheel, and running at full speed.

644. *The amount of labour*[1] *which an adult can perform may be estimated as equal to lifting from* 250 *to* 400 *tons through one foot daily.*

645. The amount of labour which workmen are required to perform, and can perform, without evident injury, is estimated by the power required to lift a number of tons 1 foot, and has been calculated as follows:—

		Tons.
Paviours' work . . .	Haughton .	352 per day.
Pile driving	Coulomb .	242 ,,
,, at the bridge of Jena . .	Lamandé .	260 ,,
Turning a lever . . .	Coulomb .	374 ,,
Pedlar carrying his load .	,, .	303 ,,
The shot drill (32-lb. shot) .	Haughton .	53·56 per hour.
Oakum picking . . .	,, .	23·74 ,,

646. Hence it may be inferred that power to lift 400 tons through 1 foot per day is the full limit of a man's capability.

647. To ascertain how high vertically a given amount of work would raise the body, the following formula is used:—

$$\frac{x \times 150}{2240}$$

where x is the height in feet, 150 the average weight of a man in lbs., and 2240 lbs. in a ton.

648. The labour of walking is estimated by the power required to carry $\frac{1}{20}$ of the weight of the body through the distance, as in the following formula:—

$$\frac{5280 \times w \times x}{20 \times 2240}$$

[1] Haughton, "Dublin Medical Quarterly," Aug. 1860.

where 5280 is the feet per mile, w the weight, x the distance, and 2240 the lbs. in a ton.

649. If we take the estimated power of the paviour, viz., 352 tons, we find that it would lift the body 1·005 miles in height, and as the coefficient of traction is $\frac{1}{20}$ or $\frac{1}{21}$, the equivalent day's work in walking is 20 to 21 miles.

650. In the tread-wheel work, however, the labour is greater, if it be continued, as is usual, during eight hours per day at the actual rate of 320 yards per hour, since it is equivalent to lifting the body through 1·45 miles, or to walking 29 to $30\frac{1}{2}$ miles per day.

651. *The excretion of urea varies indirectly with the age of the adult, but directly with the food taken.*

652. The excretion of urea has a relation to size, age, food and occupation, and is variously estimated at from 300 to 650 grains per day.

653. Warncke gives 520, 413, 390 and 310 grains as the actual quantity excreted by two males and two females daily. Haughton collected 367·5, 400·6, 465, 484·3, 554, 630, 644·6 and 677·2 grains in persons engaged in various occupations, mental and mechanical. Lehmann found that with ordinary diet, and with a minimum of water to drink, he excreted from 440 to 600 grains daily within a few days.

654. The following quantities are connected with age and weight:—

TABLE No. 48.

	Scherer.		Rummel.		Bischoff.	
Æt. years . .	22	38	31	65	43	45
Urea, grains . .	417	460	606	296	391	572

655. In these instances the proportion of urea to each lb. weight was as follows, in grains:—

TABLE No. 49.

Æt. years . .	22	31	38	43	45	65
Urea, grains . .	3·02	3·7	3·	2·	—	2·31

656. The relation is therefore between 2 and 3 grains of urea per day to each lb. weight of the body, and as the proportion of nitrogen in urea is 46·73 per cent., the daily emission of nitrogen by that substance is ·934 to 1·4 grains to each lb. in weight, whilst, as we have before shown, that of carbon is 25 grains to each lb. weight. The estimation by Beigel is somewhat higher, and results from fifty-eight observations on ten healthy men between twenty and thirty years of age, viz., 550 grains per day, and yielding 0·46 parts of urea daily for every 1000 parts of the body.

657. A doubt may exist as to whether the nitrogen which passes by the fæces is included in all of the above estimations. There is an importance in this question, for in any relations of urea to food, it is essential that the portion of nitrogen which passes off by the bowel should be included with that which was

emitted with the urine, since it must have proceeded from the food, whilst that which is found in the urine may have proceeded from any of the sources previously pointed out. Hence we may well doubt if these various returns are strictly comparable.

658. Haughton found that the ordinary vital processes of the system for the continuance of life produce an elimination of 300 grains of urea per day, or 2 grains per lb. weight of an ordinary man. This quantity is calculated by him to be equal in expenditure of vital force to lifting 769·45 tons 1 foot, or double of that required to perform a labourer's day's work. To this he adds the urea due to mechanical and mental work, and although his statement in reference to the latter is, as we shall see, open to much criticism, it is clear, that with ordinary employment, one-half more may be added to the above quantity, and the total quantity of nitrogen excreted for each lb. of the body will be at least 1·4 grain as before given.

659. In the course of more than 1000 analyses for urea made upon ourselves during the whole cycle of the year, we have found the quantity to vary in rare extremes of 350 and 750 grains per day, but in nearly all the instances the quantities lay between 480 and 600 grains. The average amount was 519 grains of urea, or 242 grains of nitrogen per day, which is almost the exact mean of all previously recorded experiments made at various seasons of the year. This quantity was derived from the urine only, and when compared with the weight of the body

(196 lbs.), gave an average of 2·74 grains of urea, or 1·24 grains of nitrogen per lb. weight per day.

660. Whilst therefore there are great variations in the amount of urea evolved both by different persons in middle life and by the same person within a few days, there is a general agreement in the whole when the quantity is compared with the weight of the body;[1] and as there are several sources whence it is undoubtedly derived, and amongst others the very variable one of the appetite and habits of eating, it is not likely that any nearer approximation will be made.

661. If therefore we consider that 150 lbs. is the weight of an average man, and that in his ordinary course of duty he evolves 3 grains of urea per lb. per day, we find an average quantity of 450 grains of urea and 210 grains of nitrogen evolved per day.

662. It is at present unsettled if the nitrogen in the

[1] There is, however, some difference in the relation of urea to body weight according to the amount of labour performed. This has been affirmed by Liebig, Bischoff, and Voit, &c., on the ground that urea is the product of tissue waste, and we have obtained some results on prisoners condemned to tread-wheel labour which in some degree confirm their view. The increase in the elimination of urea on tread-wheel days over the quantity found with light labour was, on the whole average, only 16 grains, and over the Sunday emission 34 grains daily—quantities which seem to show that violent exertion had but little influence over the excretion of urea; but the further important fact was ascertained, that the proportion of urea to body weight was no less than 4·58 grains to each lb., or a quantity twice as much as was found in ourself with a similar diet but with less labour. We may add that there was the least emission of urea on Sundays in some of the prisoners whilst there was the greatest in ourself, and for the explanation must refer to our paper read before the Royal Society in April and May, 1861.

urea represents all the nitrogen which is taken into the body in the food. The experiments of Barral deny this, but it must be remembered that the very large, nay impossible, quantity of nitrogen which he has entered as passing out by the lungs and skin, viz., 150 to 220 grains,[1] was only inferred and not collected. There is also the greatest reason to believe that some error has crept into his estimate of the nitrogen in the food, assuming that his subjects ate ordinary food, for whilst he enters it as varying from 327 to 432 grains, we have already shown, page 251, that with a very liberal scale of dietary, the nitrogen taken does not exceed 250 grains per day in this country. Hence, there is great reason to distrust the results at which he has arrived.

663. Haughton estimated the amount of nitrogen in the food and fæces as urea,[2] and determined it, as well as that of the urea excreted, and in two cases found that in one 554 grains were ingested and 549·37 grains egested, and in the other 511·1 grains were ingested, and 511·10 grains were egested per day. In this way the whole of the nitrogen in the food is accounted for, and to one not accustomed to these inquiries there might be some hesitation in receiving figures which so accurately balance each other, and

[1] "Physiological Chemistry," Dr. Day.

[2] To find the amount of nitrogen in urea (46·66 per cent.) divide the urea by 2·14; and, conversely, to find the amount of urea corresponding with a given weight of nitrogen, multiply the latter by 2·14.

he might question if there is not some accidental omission on one side or the other; but as the daily emission of nitrogen by other nitrogenous compounds cannot exceed 5 to 10 grains per day these results may well be admitted. In our own case the following is an average amount of nitrogenous food taken per day, an accurate account having been taken daily, viz.:

		Nitrogen.	
Bread . .	14 ozs. containing	81 grains.	
Potato . .	8 ,, ,,	12 ,,	
Meat (cooked)	5 ,, (including tissue and lean of bacon)	107 ,,	(Haughton).
Farinaceous food, reckoned as wheat flour .	4½ ozs. containing	35 ,,	
Tea . . .	50 grains.		
Coffee . . .	200 ,,		
Milk . .	⅓ pint . .	16 ,,	

664. This is a moderate yet abundant dietary, and although we are of very active habits and weigh 196 lbs. there is a constant tendency to accumulate fat. It is a dietary, however, which does not furnish more than 260 grains of nitrogen per day, or a little more than 1·32 grains to each lb. weight of the body per day. Hence, in our case, there is an excess of nitrogen in the ingesta of only a few grains over that accounted for by the urea in the urine only.

665. When living for 3 days on 34 ounces of bread daily, with 48 ounces of water only on the first day, and with 350 grains of tea added on the second, and 2 ounces of coffee on the third day, the amounts of nitrogen

ingested and egested made even a nearer approximation to each other.

666. Thus, with 48 ounces of bread there was an ingestion of about 196 grains and an egestion by urea in the urine of 206 grains in the day, but in the two subsequent days the nitrogen excreted fell to 195 grains, whilst that ingested was increased a very little by the tea and coffee. On the first day some nitrogenous matter was probably derived from the food previously taken, for on the day before the experiment began, the quantity of urea evolved was more than 100 grains higher; and in reference to the latter it may be mentioned that we have shown by other experiments that any alteration whatever of diet disturbs the amount of urea evolved for a short period, and hence results obtained from a few days are only approximately true. There is a compensating power in the system by which, within limits, any deficiency is supplied and any retention is subsequently discharged. It is one thing to vary the quantity of the excretions, as fæces or urine discharged from the body on a given day, and another to vary that which is really formed within the body in the same time. Bischoff and Voit have found that in flesh-feeding animals the nitrogen evolved almost absolutely accounts for the nitrogen in the food.

667. *The protection from dangers from without is at its maximum.*

668. This results from the fact that the full influence of the reason is brought to the aid of the body

in protecting it from external evils, whilst at the same time the skin is also in its more perfect condition to resist these evils, and the body in its highest state of endurance. As we have already intimated, the dangers from without are those connected with the atmosphere and most of all with temperature. In adult life the skin has lost something of the delicacy, softness, sensibility, and vascularity of childhood, and does not, therefore, so readily submit to the chilling influences from without, or permit the increased action which is necessary when there is excess of heat either from within or from without. Thus, the danger from excess of action is reduced, and commonly, if any danger exist, it will be in connection with the opposite condition. Moreover, in adult life the vital transformations are tolerably uniform and sufficient to meet the requirements of the system even when the latter may be temporarily increased; and when we add to these circumstances the power which a man has to control adverse conditions by clothing, shelter, food, and exercise, we may readily see that he is less liable to injurious influences from without than others of less age.

669. *Adverse circumstances and irrational conduct often lessen or destroy the efficiency of this protection.*

670. It may perhaps be necessary that we should qualify our observations as to the relative liability to dangers at each period of life, by stating that we refer only to the natural and constitutional conditions, and not to those which are accidental or due to the

erroneous conduct of men. There are men so circumstanced that they cannot take the full value of their advantages, but must submit to conditions which others spurn who are more free to act. There are also others who, by errors in diet or other evil habits, counteract the natural tendencies of their system, and thus again lose the advantages attaching to the various periods of life. If we would estimate all such circumstances, we should find so many data of unknown value involved, that it would be impossible to elucidate the truth, and should fall into the error which is associated with mortality returns as evidences of the tendencies to disease at the various periods of life. The natural tendencies of the human system are one thing whilst the actual conditions are another, and hence men, according to their habits and circumstances, vary in their nearness of approach to the natural course of health. Those whose conduct is the most remote from nature soon put on evidences of disease, and ere long die; but such are not types of the human system, and can only be regarded as evidencing in how great a degree the special benefits of each period of life, granted by an all-wise Providence to avert evils, may be rendered nugatory.

671. From the following table, No. 50, showing the liability to death of each period of life as determined by the actual deaths compared with the actual living population at each period, it appears that the least liability occurs from the 10th to the 15th year, and thenceforward there is a slow but progressive

increase to the termination of the ascending series of the vital actions in man, viz., from forty to fifty years of age. This is doubtless true, when the liability includes the follies, vices, ignorances, heedlessnesses and misfortunes of men, and will vary in different countries and parts of countries and in different eras with those conditions, but it is not a true indication of the actual tendency of the human system, duly governed by instinct and reason. The latter can be only shown by physiological observation, and by the actual experience of men who conform the most closely to the dictates of their nature.

TABLE No. 50,

SHOWING THE MORTALITY PER CENT. TO THOSE LIVING AT VARIOUS AGES IN ENGLAND AND WALES FROM 1838 TO 1851.[1]

AGE.	MALES.	FEMALES.	ALL.
Years. 0 to 5	7·175	6·149	6·662
5 ,, 10	·925	·922	·923
10 ,, 15	·574	·535	·525
15 ,, 20	·822	·851	·837
25 ,, 35	·997	1·051	1·014
35 ,, 45	1·260	1·274	1·267
45 ,, 55	1·839	1·589	1·714
55 ,, 65	3·190	2·834	3·012
65 ,, 75	6·721	6·026	6·374
75 ,, 85	14·696	13·446	14·071
85 ,, 95	30·202	27·417	29·059
95 ,, 100	46·169	45·200	45·685

[1] Fourteenth Annual Return of the Registrar-General, p. 16.

672. Quetelet's law of viability at various periods of life is based upon information of a similar kind to that given in the preceding table, and represents the results of all the natural and acquired causes of mortality. He found the viability of males to be less than that of females, as 3 to 2 in utero; as 4 to 3 to the second month after birth; and as 4 to 5 in the fifth month; whilst in both it attained its maximum in the thirteenth or fourteenth year.

673. It is then reduced in females during the procreative period up to 50 years of age, as it is in males from 18 to 28 years of age, when it is only half of that observed at puberty, and is probably due to the abuse of the passions.

674. *The dangers from within have reference to excess, and are due in great part to the cessation of growth.*

675. This may not appear to be true on the first consideration, since we have already shown how great is the diminution of the supply of food in relation to the weight of the body as we approach manhood, and more particularly as we have also intimated that the dangers of adolescence are those of defect. So far the statement may appear to be paradoxical, but so far also we have omitted to refer to the great change in the economy by which the increasing growth is now arrested, and a state of equilibrium established. This we believe to be the essence of the change, and by it the amount of nutriment which the body will receive will be less under the guidance of instinct than was

the case during the period of excessive requirement or growth, and hence be more liable to abuse.

676. It can scarcely be but that the vital processes themselves shall lead on to disease from excess, when hitherto they have been maintained at a rate much beyond the amount needful to keep the system *in statu quo,* and now (influenced by an inscrutable law of Nature) are more or less suddenly restricted. We know that ordinarily there is a manifest tendency in the body to balance its own account of want and supply, but we know also that this is a struggle, and that there is constant liability to an increase in the direction in which the preponderating vital forces are then tending; and whilst in adult life the balance will be ultimately struck, it will not be until the efforts made to restrain the previously implanted tendency to increase have, from time to time, brought the system to the threshold of disease.

677. To this we may also add the disposition which is common to men to indulge their appetites, and when occasion offers, to take more of certain kinds of food than the wants of the system really require. This will be manifestly more influential at the period of life when the bodily desires and appetites are in their full vigour and demand indulgence, whilst at the same time the cessation of growth of the body is as constantly calling for a limitation in the supply of nutrition. The result of this tendency to excess is seen in the increased accumulation of fat in some cases; in others, in the increased elimination of urea;

and in all, in a tendency to congestions, to inflammations, and to diseases which are more sthenic than those found at any other period of life. Acute and sthenic conditions are those which mark the derangements of middle life, whilst those of a chronic kind have originated in adolescence, or are found, as we shall soon show, in old age. At this period of life above all others are we liable to derangements of the liver and chylopœtic viscera—indeed, they constitute the mass of cases in daily medical practice—and result from the law which we are discussing. At this period of life, moreover, above all others, are we cautioned to maintain free action of the bowels and skin; the former, for the removal of effête matters from excess of food, and the latter, to prevent excess of heat likely to accrue from the excess of vital action. The former injunction is so necessary that many persons are compelled habitually to take medicine to aid the action of the bowels, and the latter is furthermore necessary from the fact that the rough and dry skin of exposed men is less disposed to excess than to defect of that action which, by transforming fluid into vapour, reduces the temperature of the surface, and the volume of the body.

678. It may also be worthy of remark that the substances in food which are accounted rich, and in which adults are liable to indulge, have not only the property of exciting the vital actions, but they at the same time tend to lessen the action of the skin, and thus disturb the balance of want and

supply. This is the case with meat, fat, milk, and alcohols.

679. These considerations are further supported by scientific research, for we have shown that whilst the evolution of carbon and urea increases in adult life with the size of the body, and therefore with accumulated material, it decreases very slightly with age, thus showing that within certain limits the natural course of the system would be to lessen rather than to increase its vital transformations, and such we believe also to be the result of individual experience.

680. We, therefore, urge the great importance in adult life of limiting the supply of nutriment to the strict requirements of the system, and to follow the good example of those who leave the table without having fully satisfied their appetite, and before any marked sense of oppression and interference with mental activity occurs.

681. *Mental labour is advantageous to health, and when in excess lessens and does not increase vital transformation.*

682. This is a fitting occasion on which to consider the influence of mental labour over the animal economy, since, although it begins in adolescence, it attains its highest standard and most prolonged duration in adult life, and conjoins with it those excesses of mental effort which are called anxieties.

683. Every one is conscious of exhaustion after severe and long-continued mental labour; and it is

of every-day experience, that when mental work is too long continued the bodily health fails. But although this be true, it has not been shown in what way the mental effort has directly led to this result; and as there are many attendant circumstances which are of themselves very likely to lead to evil, it may not be always easy to eliminate the true influence of this particular agent. In reference to direct results, it has been stated that there is an increase in the elimination of phosphorus in the urine of lunatics in the fury of madness; and it has been thence inferred that this has resulted from the unusual excitement of the brain and nervous system; and further, that it is probably true of all kinds of severe mental exertion. This statement must be taken for what it is worth, but to our minds it has but small value, and certainly it has not been shown that the effects of great mental labour and anxiety have been relieved by supplying an increased amount of phosphorus to the body.

684. Haughton has (as above mentioned) attempted to show that there is an increase in the elimination of urea proportioned to the amount of mental labour, but in many important points this statement is inconclusive. Thus, in one direction he assumes that mental labour will cause waste of tissue in the same degree as has been proved to occur with bodily labour, and then determining the number of hours, and estimating the severity of the labour, he determines the amount of urea evolved on the formula before given. In another direction he seeks the result by attributing

to mental work, or anxiety, that amount of urea which is not accounted for by the vital and mechanical work with or without such addition as he has made for mental labour. For hard mental work he allows 43·4 grains of urea per hour, and for routine work 27·71 grains per hour.

685. But however ingenious such a course of inquiry may be, it is far from being demonstrative. Moreover, we have proved abundantly that mental labour in no degree increases the exhalation of carbon, but, on the contrary, lessens it in the proportion in which the body is kept at perfect rest; and when we recollect that the most insignificant amount of muscular exertion increases the evolution of carbon, we cannot but doubt if the one kind of labour can in any way be the measure of the other. We cannot but think that the action upon the vital processes by mental labour is the reverse of that assumed by Haughton, and that it is diminished in proportion as the nervous power is abstracted from the body and directed to the mind.

686. The sense of exhaustion which follows mental labour may surely be as philosophically associated with defective vital action from defective nervous influence, by which the nutritive and reparative actions are enfeebled, as by an increase of action to a degree exceeding the supply. Moreover, it is a rule in reference to bodily labour, that with the increased waste which it causes there is an increased demand for food, but with much mental labour there is usually asso-

ciated lessened desire for food, and, as we all know, lessened nutrition. The only *primâ facie* objection to this statement is the belief that the brain and nervous system by excessive labour must undergo excessive waste, and increase the urea and phosphates in the urine. But admitting this to be so for the sake of argument, the proportion of the brain to the whole body is such that its waste could not be compared to that of the muscular system under exertion, and might be counteracted by any small diminution in the action of the latter. And in reference to the production of urea from waste of tissue by exertion, we must refer to what we have already written with a view to show how small is the effect of increased muscular exertion in producing increase of urea.

687. It is a common, and doubtless a truthful remark, that the study of the man of learning is as fatiguing as is the labour of the handicraftsman, and the only difficulty is to ascertain in what way this occurs.

688. The indirect action of mental labour upon the health of the system and in inducing a sense of fatigue is very well known. The constrained posture for a lengthened period, whether it be in the chair at home or in the railway carriage, will induce fatigue. The want of the muscular exertion which sustains the current of the blood, and increases vital action; the want of movement in the surrounding air; the less pure condition of the inspired air; the higher temperature and the lessened light of the sitting-room are

all surely so many causes tending to lessen vital action, and to lower the degree of health of the body. But all these, so far from increasing, will certainly lessen the amount of urea and carbon evolved and of food ingested.

689. The remedy for the effect of mental labour is bodily exertion in the open air, which will increase the vital action, the appetite, and the excretion of urea; so that if Haughton's views were correct, this would be a patent illustration of the minor (although stated as the major) premiss, "Similia similibus curantur."

690. But it may be admitted on the common experience of mankind, that a moderate amount of mental attention, when conjoined with suitable bodily labour, increases the vital activity, the pleasures, and the usefulness of man, and, as such, should be cultivated. It is its excess which is injurious, and especially by interfering with the bodily habits.

CYCLE OF THE AGES OF MAN.

CHAPTER VIII.

DESCENDING SERIES.

OLD AGE.

691. We now proceed to consider a state of the system about which there can be but little difference of opinion in either scientific or non-scientific minds. That there is a descending series of phenomena in advanced life is universally admitted, so that feebleness and decrepitude are held to be the natural characteristics of old age.

692. *The age at which the descending series commences is variable.*

693. We have already stated that there is no interval between the ascending and descending series, but the former insensibly merges into the latter. Hence it is only when the downward tendency has become predominant, and not when it is established, that we are conscious of the change, and as those who have lived the most closely to the dictates of Nature

retain the ascending series the longest, the period of change cannot be defined by the years of life. Hence some are old when in the middle years of human life, whilst others retain their vigour and freshness when the middle years have long passed away.

694. *The characteristic of old age is not simply an excess of waste over supply, for whilst in many old age may be represented by the wrinkled face and the shrunken limbs, in others it finds the body yet plump and with good store of material, but it is essentially in the enfeeblement of each set of vital powers.*

695. We have already shown that the amount of the excretion decreases in old age both absolutely and in relation to the weight of the body, so that whilst the daily excretion of urea to each 1000 parts of body-weight was $9\frac{1}{2}$ grains at 18 years of age, and 7·87 grains at 31 years of age, it fell to 5 grains at 65 years of age.

696. The carbon in like manner, after increasing in absolute quantity until middle life (40 to 45 years, Andral and Gavarret), thenceforward decreases. We have not the means afforded of estimating with absolute accuracy the relation of the carbon to the weight of the body, but on Andral and Gavarret's authority we find that three men, all of moderate muscular development, aged 37, 59, and 68 years, expired 164·7, 154, and 147·8 grains of carbon per day respectively, which showed a progressive diminution of about ·07 grains daily for each advancing year of life. It is true that as the researches of these eminent men were continued

for only about 1 hour per day upon each person, they are not adapted for the determination of the whole evolution of carbon for the day; but it is probable that the general results now given are correct. Our own experiments already detailed (630) have also proved that there is a progressive and proportionate diminution of the excretion of carbon to the weight of the body year by year even up to so early a period as 48 years of age, although it went only to the extent of about $\frac{1}{3}$ of a grain for each 5 years of advancing age.

697. Hence it may be affirmed that the decrepitude of old age and the termination of life are not due simply to an increase of waste proceeding as life advances.

698. There is much evidence to show that the failure of life is due to a diminution of all those actions which characterise life and the various exhibitions of vital power which are seen in its consecutive eras. The substance of the heart and of the muscles in general becomes fatty, so that the *situs* of the muscular fibre is in part occupied by oil, and the tone and power of resistance of the tissue is lessened. The rate of respiration declines, but that of pulsation somewhat increases. Table No. 36, see p. 262.

699. The vital capacity of the lungs decreases, the vesicular murmur is much less intense, and the movements of the chest are restricted. Indeed in all cases of advanced age there is a distinct dullness on percussion of the clavicles, due not to the deposition of solid matter, but to the contraction of the lungs at the

apices, and the deficient expansion of the lungs by which the proportion of the air to the tissue is greatly lessened.

700. The size of nearly all the organs of the body is lessened, as those of the lungs, kidneys, brain, and muscles. The vital tonicity of all tissues is reduced, as is also the strength of the bones by reason of a deficiency of animal tissue. The blood contains a larger portion of water, less albumen, and fewer red corpuscles. The appetite is lessened, as is also the relish for food. The function of digestion is less actively performed, and the bowels become torpid. The skin is less sensitive, and becomes loose and lax.

701. These and other similar changes do not show increased activity of the vital processes by which waste is increased, but a reduction of all the vital powers. The accumulative and formative functions are lessened to as great an extent as the excreting function.

702. It is fashionable to speak of "Retrograde Metamorphosis," and to assert that the replacement of muscular tissue by oil is the result of this change in the vital actions; but it appears to us that nothing is gained by the use of such a term that would not be gained if we considered that the formative function in a given situation is lessened; and by the latter course, we do not involve ourselves in a further confusion of ideas.

703. *The dangers from without are increased, and there is a diminution of the powers of resistance.*

704. This results from the chronic diminution of the heat-production within the body, by which the old are rendered less independent of extraneous aid in maintaining a due temperature. Hence in old age shelter from inclement weather, an abundance of non-conducting clothing, and exposure to artificial heat are prime necessaries of existence. In these respects the conditions again approach to those of infancy, and to them may be added a lessening degree of consciousness and capability of exertion, but it differs from that of the infant in that the system is far less sensitive, the skin far less active, and the vital actions proceeding in the body far less vigorous. The danger therefore is still less than that which occurs in infancy, and this corresponds with observation as to the effects of exposure to cold and hunger upon these two more feeble sections of the community.

705. *The dangers from within are at the maximum.*

706. This is shown in a general manner in the mortality returns in Table No. 50, which prove that, whilst there is a parity in the proportionate mortality of infancy and old age up to between 60 and 70 years of age, the liability rapidly increases after the latter period, and ultimately attains to four-fold the amount in infancy.

707. *The dangers are altogether such as result from failure of the vital powers.*

708. Such are the diminished supply of nutriment and lessened power of transformation of food and formation of tissue; lessened aëration of the blood;

lessened power of excretion of effête matters; diminished support to the circulation, whereby congestion occurs in the most vascular organs, and effusion of serum into the shut cavities and depending parts. There is also imminent liability to sudden failure of the heart's action ; diminished elasticity of the arteries, and liability to their rupture ; and in general, lessened power of adaptation to new circumstances and of resistance to adverse influences. In the longest life, and in one who has duly fulfilled the indications of Nature in the management of his body, death must ensue from failure of the vital powers to maintain the current of the blood and the required temperature, whilst those who die at any earlier age succumb to the influence of accidental evils.

CYCLE OF THE AGES OF MAN.

CHAPTER IX.

SUMMARY AND APPLICATION TO HEALTH AND DISEASE.

SUMMARY.

709. We have now considered the principal conditions of the human system in the different eras of a man's life, and the leading ideas in the contrast of these eras which have been developed may be thus summed up.

710. In infancy there is the maximum relation of both azotised and non-azotised food to the weight of the body, and this declines gradually through childhood, rapidly at adolescence, and slowly through adult life to old age. There is the greatest sensibility, the highest degree of animal temperature, and the most active state of the skin. This lessens slowly through childhood to adolescence, finds its medium condition in adult life, and its minimum in old age. In childhood and youth there is the greatest excretion of carbon and urea to the

weight of the body. This declines rapidly in adolescence, and thenceforwards very slowly until the end of life.

711. In adult life we find a state which is medium in degree, uniform in character, and prolonged in its duration.

712. The protection against dangers from without is the least in infancy, then in old age, then in childhood, and the greatest in adult life.

713. The dangers from within are the greatest in old age and in infancy, then about puberty and in adolescence, and the least in adult life.

714. The diseases occurring in infancy and adult life are more acute in their character, but in the former they are asthenic, and in the latter sthenic, whilst those which occur in adolescence and old age are chronic.

715. Old age is established in childhood, but manhood in adolescence.

716. In adult life the danger from nutrition is from excess, but in old age, adolescence, and infancy, from defect.

717. In infancy there is the greatest, and in childhood a less amount of danger from an erroneous dietary, whilst in adult life there is the greatest tolerance of such errors.

APPLICATION TO HEALTH AND DISEASE.

718. We shall now conclude this part of our work by a few additional practical remarks in reference to

the requirements of the several periods of life which have now been discussed.

Infancy.

719. In infancy the leading indication is manifestly an abundant supply of nitrogenised food, and due conservation of the temperature of the body. To this end, a supply of milk of average composition should be afforded and served without stint; and should the nurse's supply fail, the want should be supplied by milk with the composition rendered artificially similar to that of the mother's milk. This may be cows' milk, diluted with a quarter of warm water and with a little sugar added. When starch is given, the quantity of milk should not be materially lessened, and the greatest care must be taken to prevent fœcal accumulation. Nitrogenised food does not tend to accumulate in the bowels, whilst starchy food induces constipation primarily, and diarrhœa with other evils secondarily.

720. *An admixture of cows' and asses' milk is the most perfect substitute for woman's milk.*

721. We have attempted to tabulate the most readily attainable kinds of milk, with a view to show in what way their composition might be artificially varied so as to approach the standard required, viz., woman's milk, but the vast diversity in the analyses by different chemists, and even by the same

chemist in different specimens, renders such an attempt almost nugatory.

722. The following is the nearest approach which we can make to a rational comparison.

TABLE No. 51,

SHOWING THE AMOUNT OF THE FOUR PRINCIPAL ELEMENTS OF MILK.

	Standard.	Cows'.	Asses'.	Goats'.	Mares'.	Ewes'.
	[1]per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Butter	3½	4	1¼	3½	·8	5·
Casein	3½	6½	2	5 to 6	1·62	5·+
Sugar	4	3	6	4	8·75	4½
Salt		·65	·34			·7

723. Hence it would seem that goats' milk approaches the nearest to human milk, and would be its best substitute, were it not for the disagreeable hircic acid which is found in the butter. It is probable that the excess of casein would not lead to any evil results.

724. Asses' and mares' milk are remarkably deficient in butter and cheese, and hence cannot be substituted for human milk when the design is to supply abundant nutriment,—the deficiency being so great that two to three pints would be required to supply one pint of standard milk. The excess of sugar would probably not be injurious. Ewes' milk is the richest milk with which we are ac-

[1] Multiply by 87·5 to obtain the quantity per pint.

quainted, and would require a dilution of something more than one-third and the addition of sugar.

725. Hence it appears that cows' milk, from its composition and abundant supply, must ever be the substitute for human milk, and its composition may readily be changed to the standard quantities. Attempts have been made to improve the quality of asses' milk by the addition of suet; but it is to be observed that the fat is not thus reduced to the minute globules which are found in natural milk; and, moreover, there is a great deficiency of nitrogenous material. Asses' milk, when given alone, must soon impoverish the system, and cannot be perfectly adapted to the wants of the child by any addition of starch or fat, but it is most excellently fitted for the attenuation of cows' milk, since it affords but little of that which we would take away, and much of the sugar which is required. Equal parts of cows' and asses' milk would no doubt be a very advantageous mixture.

726. If the standard milk be found insufficient to well nourish the system, it would be better to use goats' milk than to add any considerable quantity of starch.

727. *The warmth of the body is the most effectually provided for by the warmth of the nurse's body.*

728. In reference to warmth, we may affirm that the warmth of the nurse's body, and that induced by warm clothing, is much better than the restriction to a warm atmosphere, for it is uniform and of the right

temperature, and does not tend to vitiate or to dry the air to be respired.

Youth.

729. In youth the leading requirement is still abundant nourishment, and to this should now be conjoined the free use of the limbs in the open air. Sitting avocations and confinement to close rooms must be injurious. In reference to temperature it is very probable that free exposure to a moderate degree of cold is desirable, since it will tend to excite muscular exertion, to lessen the action of the skin, to increase chemical changes and to excite the consumption of food, and at the same time there is vital energy enough to resist the depressing influence of a moderate degree of cold. Should the skin be soft and sensitive it is desirable that it should be wiped with a towel simply made wet (but not saturated) with salt and water, with a view both to accustom the skin to the influence of cold and to excite the development of a thicker epidermis. We attach the greatest importance to the acquisition of a condition of the skin in which its sensibility shall be moderately restricted, in the belief that nearly all the ills which arise in early life in this climate are due to impressions made upon the skin.

Puberty.

730. At puberty there are doubtless new conditions to which attention must be directed in females, and

which may either lessen or increase the tendency to disease. The nervous system is certainly exceedingly sensitive at the period when the menses are first established, so that it needs unusual protection, whilst at the same time the menstrual discharge not unfrequently seems to exhaust the system when it commences at an early age. It becomes therefore a duty to supply an abundance of azotised food, and at the same time to maintain such an amount of bodily exertion as shall sufficiently excite the vital actions.

731. The due and proportionate development of each part of the body, and especially of the lungs, should be most carefully watched, and any evil tendency counteracted by gymnastic exercises, calisthenics, and regulated inspiration. It is commonly found that any tendency to deformity of the body or want of symmetry originates in a defective state of the nutritive and formative processes which has existed long prior to the period when its manifestations attract attention, and it thus offers an additional reason for an early and continued supply of proper nutriment, so as to prevent the necessity for cure.

732. There is a natural desire for much sleep during infancy, childhood, and youth, and there is much reason for its free indulgence. In infancy the waste of the body is thus lessened, whilst in the growing years of youth and adolescence the horizontal posture relieves the pressure upon the yet feeble heart and permits a more even distribution of blood to the body. It is probable also that the slower rate of pulsation

which then occurs is favourable to the formative process. Hence, sleep and the horizontal posture should be almost unlimited in infancy, and although regulated, yet largely indulged in during the whole period of growth, and particularly in those cases in which development is very rapid, or the power of the heart is enfeebled.

Adolescence.

733. *In adolescence the most patent evils are associated with sexual abuse and excess.*

734. The former of these evils too commonly results from communication with evil associates, and particularly at school, and ought to attract the vigilant attention of those to whose care youth is committed. Listlessness, a dull, sluggish, and haggard expression of countenance, with flitting muscular pains and ill-defined marks of ill health, may well attract notice, and should abuse be detected the most rigorous watchfulness should be exercised to prevent it. It is impossible to sit in the out-patients' rooms of our hospitals without seeing many who are evidently suffering from past abuse, and in an inquiry in which we have long been engaged, we find many men who acknowledge and deplore this evil. It certainly is a fruitful source of nervous prostration, and thereby of phthisis.

735. The evils of excess are not known even to professional men to their full extent, but there are good grounds for believing that they have led in great measure to the avoidance of the married state

by young men, which is now become one of the sins of the day. It is a matter into which we cannot here enter, but it is deserving of the closest attention both of our own profession and of the heads of families. The excess of mortality which occurs after puberty (Table No. 50, p. 313) is by some attributed to this evil, but whilst this may be one of the sources of the mortality, it is more probable that the evil results assume a more chronic form, and affect the system fatally about middle life.

736. *Alcoholic liquors and smoking tend to the injury of the system.*

737. The avoidance of alcoholic liquors and of smoking is also a habit of prime importance. The contrary course in reference to the former disturbs the harmonious working of the system, and especially the due control which the skin should maintain over the vital actions, and by the reaction of its effects must lower the tone of the system. The use of alcohols should certainly be exceptional, and happy is the man who passes through this period of his life without being ensnared by either of these evils. The action of tobacco must certainly be antagonistic to health, and although its effects may not always be evident to the observer, they are oftentimes secretly known to the victim. It is not enough to say that many smoke through a long life and find no evil, since it can be proved that many others are seriously injured by it. Its influence over impotency in adolescence is said to be well established in the minds of

those members of our profession, who have frequent means of determining it; and its ill effect upon the throat in inducing pharyngeal, laryngeal and probably pulmonary disease is a circumstance of our own daily observation. Abundant food should be given, and the appetite should always be satisfied.

738. *Gymnastic exercises are of great value.*

739. The importance of gymnastic exercises, in giving not only due development to the body, but also vigour and strength, cannot be overrated. It is in this direction that the rifle movement of the day is likely to render the greatest service to the health of the present and the next generation, notwithstanding the probably increased exposure to some of the evils which have been referred to under the head of adolescence, since it gives a defined direction to muscular effort, and calls for its frequent employment. It is yet to be desired that every corps, as indeed every school, throughout the country, had in addition its well arranged system of gymnastics, so that agility and elasticity, as well as force and endurance, might be increased in our youth. There should also be free exposure to the air associated with exertion, and enough but not an excess of clothing, so that in the cool weather the full healthy effect upon the skin, and thereby upon all the vital functions, should be experienced.

740. The habits and the condition of system acquired in adolescence, will, in all probability, become unchangeable through life.

Adult Life.

741. *The indication of adult life is to maintain an equal balance of all the functions of the body, and of the action and reaction of the mind and the body.*

742. The avoidance of excess in every direction is the happiness and the difficulty of this period. It is seen in the direction of food in one, of muscular labour in another, of mental labour in a third, and of business anxiety in a fourth type of manhood, so that if it were not for the wonderful power which the body possesses of adaptation to evil conditions, and of recovery from evils induced, the life of man would speedily come to an end. It cannot be denied that man, with his reason, is far less careful of his health than the brute which roams over wilds where man is not found, guided by instinct alone, and is infinitely more prone to excess in food, passions, labour, or idleness. In the advance of time, as man approaches his higher destiny, it must be seen that he will strive to regulate his worldly acquisitions by his necessities, and his appetites by the strict requirements of his body.

743. The sum of all the cautions suited to adult life is contained in the word "moderation."

Old Age.

744. *Old age lives on the past, both in reference to the mind and the body, and if a store of food for both have not been provided in earlier life, it is but rarely that the want can be supplied.*

745. Old age requires the aid and care of others, and an abundant supply of food of a highly nitrogenised kind, in proportion to the weight of the body, so as to aid the failing powers of alimentation and nutrition. The appetite should be fully satisfied, for commonly it also fails somewhat, and the only limitation to the supply of food should be the due excretion of the products of it. At this period we become involved in the most difficult problem of life, for whilst the failing powers call for an abundant supply, the powers of digestion, and also of excretion, are incompetent to make use of it. Hence, whilst there is a constant tendency to defect, there is also a constant tendency to excess, and the system requires aid in both directions.

746. A green old age is the treasure of the man who has lived near to Nature, and who has acquired habits which will still serve him in old age, and which he will not be induced to change. These habits have necessarily included a large amount of daily exercise, and whilst rest of body and mind seem to be longings of age, they should be kept under due control. It is true that to increase waste is not the indication of old age, but to increase vital action should be the daily aim.

747. Lastly, great attention to the conservation of the heat of the body is a prime requirement.

748. Dr. Carpenter, in his excellent work on "Physiology," has a note, in which he shows in a striking manner the influence of low temperature

upon the old. It gives the proportion of deaths occurring in the first two months of 1855, compared to 100,000 persons living at the several ages, and is as follows:—

TABLE No. 52.

Age.	Deaths to each 100,000 living.
Years. 0 to 20 Years.	40
20 ,, 40	22
40 ,, 60	87
60 ,, 80	512
80 and upwards.	2073

749. This shows a frightful mortality in old age, but in regarding the true value of this *average*, due allowance must be made for the small numbers living above eighty years of age within the bills of mortality, when compared with those of middle and early life, and which therefore give an unstable average. Nothing, however, could more vividly show with what certainty cold kills the aged.

750. In how great a degree are the requirements and dangers of infancy and old age alike.

CYCLE OF THE GENERATIONS OF MAN.

CHAPTER X.

GENERAL OBSERVATIONS.

751. There is reason to believe that the constitution and powers of man have remained much the same since the earliest days to the present time, subject to the well-recognised influence of climate and race, and to temporary causes of variation. The information which the Sacred writings afford in reference to the Israelites and the nations with whom they fought, as well as the descriptions of men given by the fathers of poetry and history relating to the inhabitants of widely different countries, prove that man in those distant ages had the same powers, wants, and dangers as we have now.

752. Moreover, the short descriptions of disease left by Aretæus[1] are as applicable to mankind now as they were in the middle of the second century of

[1] Sydenham Society, book i. p. 300, translated by Dr. Adams.

the Christian era, as the following life-like portrait of an advanced consumptive may well prove.

753. "There is present, weight in the chest (for the lungs are insensible to pain), anxiety, discomfort, loss of appetite; in the evening coldness, and heat towards morning; sweat more intolerable than the heat as far as the chest; expectoration varied as I have described." . . . . "Voice hoarse; neck slightly bent, tender, not flexible, somewhat extended; fingers slender, but joints thick; of the bones alone the figure remains, for the fleshy parts are wasted; the nails of the fingers crooked, their pulps are shrivelled and flat, for, owing to the flesh, they neither retain their tension nor rotundity; and owing to the same cause, the nails are bent, namely, because it is the compact flesh at their points which is intended as a support to them; and the tension thereof is like that of the solids. Nose sharp, slender; cheeks prominent and red; eyes hollow, brilliant and glittering; swollen, pale, or livid in the countenance; the slender parts of the jaws rest in the teeth as if smiling; otherwise of a cadaverous aspect. So also in all other respects; slender, without flesh; the muscles of the arms imperceptible; not a vestige of the mammæ, the nipples only to be seen; one may not only count the ribs themselves, but also easily trace them to their termination; for even the articulations at the vertebræ are quite visible, and their connections with the sternum are also manifest; the intercostal spaces are hollow and rhomboidal, agreeably to the

configuration of the bone; hypochondriac region lank and retracted; the abdomen and flanks contiguous to the spine; joints clearly developed; prominent, devoid of flesh, so also with the tibia, ischium and humerus; the spine of the vertebræ, formerly hollow, now protrudes, the muscles on either side being wasted; the whole shoulder blades apparent, like the wings of a bird. If in these cases disorder of the bowels supervene, they are in a hopeless state."

754. So in like manner the extracts which we have already given from the works of Hippocrates (259 *et seq.*), and his treatise on airs, waters, and places, prove that the influences of climate and season upon man, nearly 21½ centuries ago, were the same as at the present day.

755. But whilst this may be admitted, it in no wise proves that there have not been variations in the human constitution fitted to influence the character of disease, some of which would run an acute course, and recur in cycles of a few years' duration, as in the instance of the recurrence of epidemics; whilst others would occur slowly and in a somewhat defined order in the various social changes which proceed in the rise, progress, and decline of a nation.

756. As we know that the constitution of man is easily and powerfully influenced by the social and meteorological conditions which attend him, it is impossible to doubt that it has changed in the progress of every nation which has passed through the stages of barbarity, plenty, abundance, effeminacy, and decay

in their order, and that his diseases and liability to disease have varied accordingly. The value of epidemics as evidences of similar changes in the shorter period of a generation may not be so readily admitted, but a little reflection will show that the changes which proceed in the duration of a nation's history have advanced step by step with each generation, and have been due to causes which have influenced the inhabitants of that age as much as the whole changes of eras have affected the inhabitants during its whole history, and through their offspring, born under these exceptional conditions, would influence the next one. We have evidence of a change of constitution in our own times—one which has occurred so suddenly that men of forty years old can bear witness to it; and hence we find a probability that similar changes affecting the general character of diseases may have occurred a thousand times in the world's history. These were due to causes many of which are now beyond our research, or the limits of our present knowledge; but they must surely be found in association with the changes which proceed in the habits and manners of society, and in the conditions of the soil, season, climate, and general social arrangements of the period. Epidemics have commonly arisen from social conditions unfavourable to health, as periods of general political anxiety, social degradation, or famine, and are illustrations quite as pertinent of the increased aptitude of the system to succumb to adverse influences as of the existence of a

general exciting cause which probably originated from without. These would give us cycles of changes of a shorter duration than those which affect the whole history of a nation, but it is probable that the true character of the changes in the former would be even more truly cyclical than those of the latter.

757. We purpose to briefly consider the two series of changes to which we have now referred, viz., the occurrence of epidemics as evidence of rapidly recurring periods of unusual liability to disease, and the changes in the habits, wants, and dangers of society.

CYCLE OF THE GENERATIONS OF MAN.

CHAPTER XI.

THE OCCURRENCE AND THE CAUSES OF EPIDEMICS.

758. As our purpose is not to write a history of epidemic diseases, nor to minutely describe the nature of each epidemic, but rather to note the period of their occurrence, the extent of their prevalence, and the conditions under which they were found, we shall not carry our researches back into times so distant that the attendant conditions and the nature of the disease are now only conjectural, but shall chiefly refer to the epidemics which prevailed in the middle and later ages of society.

759. The essential idea in the occurrence of an epidemic is that of a disease either of a known or unknown kind, which attacks mankind with *unusual* prevalence, or with *unusual* virulence, so that a large mass of the people become afflicted by it, or large numbers die from it. *The unusual prevalence and the*

great mortality are the questions which attract our attention at present, and clearly indicate the occurrence of causes of disease acting temporarily with unusual power, or a state of system which is unusually deficient in its power to resist the causes of disease, or it may be that both these conditions occur at the same time.

760. *Occurrence of epidemics.*—Limiting our attention to the Christian era, it is to be remarked, that there has been no century without the repeated occurrence of these conditions, and that the cycle has occupied so short a period as from ten to twenty years. Thus, we find on record six principal epidemics in the 1st century; five in the 2nd; six in the 3rd; five in the 4th; eight in the 5th; three in the 6th; two in the 7th; ten in the 8th; three in the 9th; seven in the 10th; thirteen in the 11th; ten in the 12th, and thirteen in the 13th century, which carries us down to the period when historical records enable us to enter into accurate detail as to the nature, causes, and prevalence of those fearful scourges of mankind.

761. The epidemics which are recorded in the first centuries of the Christian era were necessarily found in Italy, or other countries subject to Rome, since at that period nearly every nation which has left a written history was subject to that great power. The pestilences which occurred in Rome in A.D. 67, and in many parts of the world in A.D. 252, 539, 590, 715, 771, 1230, and 1252, were amongst the most mortal of those which appeared before the 14th century.

762. The 14th century was rendered memorable by the occurrence of the most fatal epidemic of the Christian era, which received the apt designation of *The Great Mortality*. It is stated that throughout Europe whole villages and towns were desolated by it, so that Spain alone lost twenty millions[1] of her inhabitants, and England one-tenth[2] of her whole population.

763. Its nature was that of the oriental plague. In Constantinople and the East it commenced with bleeding at the nose (a sure sign of inevitable death), and was indicated by buboes on the extremities, which opened and discharged offensive matter, whilst there were smaller boils and blisters on the body, and black spots either single or confluent. Cephalic symptoms, as stupor and loss of speech, were found in some, whilst there was blackness of the fauces and tongue, with the most burning thirst, in others. In the West the fever and the evacuation of blood were the most important symptoms, whilst buboes followed at a later period of the epidemic; but in Italy tumours in the groin and axilla, called pest-boils, were observed at the commencement. In England the mortal spitting or vomiting of blood and the inflammatory boils and buboes were the common signs of the disease. To these must be added that of contagion, which was everywhere observed. The duration of the disease was from twelve hours to three days. Hence the

[1] Forster on "Disease and Health."

[2] *Et seq.* Hecker's "History of the Epidemics of the Middle Ages."

general corruption of the body, the congestion or low inflammation of the lungs, and the nervous prostration were the universal evidences of the disease, although the plague extended from China, Turkey, and Egypt, through Italy, Spain, France, Germany, and England, to Russia and Poland. It was also to some extent communicated to animals, for many of them, as dogs, cats, fowls, and pigs, died of it. In England the murrain seized the cattle when wandering about without herdsmen, and they died and tainted the air by thousands.

764. There were seventeen outbreaks of the plague in different parts of Europe during the 15th century, at a time when much commercial intercourse was carried on by sea. At this time quarantine (or a separation for forty days) was established in Italy and other parts of the south of Europe, and bills of health were first introduced in the following century, viz., in 1527.

765. During the 14th and 15th centuries *Dancing Manias* were exceedingly prevalent throughout the south of Europe, Germany, and France, and have left their representatives in the St. Vitus' dance and the hysteria of this day. These dancing manias were called *St. John's Dance*, *St. Vitus' Dance*, and *Tarantism*.

766. *St. John's Dance* was probably in some measure excited by the Bacchanalian dances which from the remotest times were associated with St. John's day, a festival solemnised with all sorts of rude customs, in which the mysticism of the Christian religion was added to relics of heathenism. At this festival it was

common to leap through flames, in the belief that animals and men would thus be protected for a whole year from fever and other diseases by this baptism by fire. Hence the wild revelling and the violent jactitation of the day, superadded to a superstitious mysticism, naturally led, at a period of unusual depression in the vital powers, to the plague of dancing.

767. There did not appear to be any distinction between St. John's dance and St. Vitus' dance, except in name, and whilst that of St. John referred to the probable origin of the disease, that of St. Vitus arose from the assistance which the Sicilian youth was presumed to render towards its cure.

768. *Tarantism* was supposed to have originated from the bite of the Tarantula, a large black spider, which at this day is known to be poisonous, and which then abounded on the banks of the river Thara, near the city of Tarentum, in Italy. The immediate effect of the bite was stupor, melancholy, and great oppression of the senses, but when music was introduced, the patients sprang up and danced in the most violent manner until their strength failed them. Hence originated numerous airs or dances, called the Tarantula, of various kinds, to suit the passions of those who were afflicted with this disease, and many bands of musicians travelled through the country to afford the aid of music to such persons. It is however to be observed, that the music was used as a remedial agent, with a view to excite the muscular movements, just as at the present day it is an express injunction that any

one who is bitten by a Tarantula, or centipede, or poisonous snake, shall be kept in constant motion, so as to avert the evils of the stupefaction of the senses and the depression of the vital powers; and hence music became the remedy in the hands of a music-loving people for diseases having a similar character, and Tarantism soon included other conditions than those originating in the bite of the Tarantula. It should also be observed, that the practice of dancing was also promoted by persons in health voluntarily joining in the dance, in order to enable the victims to maintain the exertions; and indeed the magistrates of various towns provided strong persons for this purpose, from a general belief that only by such violent and long-continued exertion could relief be afforded. During this exertion the afflicted drank wine freely, but without the least approach to intoxication.

769. Associated with the foregoing class of disorders was *Hysteria*, a disease which found relief in the violent and lascivious dances of that period.

770. We will now refer to some of the more important circumstances which attended the various eruptions of the epidemic known as the *Sweating Sickness* in the 15th and 16th centuries, and of which no fewer than five visitations occurred in England in the years 1485, 1506, 1517, 1528, and 1551, the second and the fifth after intervals of 21 and 23 years, and the third and fourth with intervals of half that duration. The general character of the disease was an inflammatory rheumatic fever, with

great disorder of the nervous system. There was a disturbance of the relation between the functions of the skin and the organs of organic life. The most evident feature was profuse sweating, whilst the subsidiary ones were symptoms of oppression of the brain and nervous system. There were great dyspnœa, anxiety, nausea, and vomiting, with stupor and profound lethargy, and torpid circulation. The attack of 1517 was particularly virulent, and life endured but a few hours. On the Continent it was accompanied by a malignant sorethroat, which attacked both the œsophagus and air passages, and covered them with a white layer like mould, and was no doubt an attack of diphtheritis.

771. There were scarcely any premonitory symptoms in the various attacks, except signs of fainting and great exhaustion, but sometimes there was a shivering fit followed by creeping sensations or formication and weariness, as in common fevers, and an obscure pain in the head, which preceded the lethargy. In many the countenance was bloated and livid, or there was remarkable dyspnœa with palpitation and a stinking sweat. Sometimes there were convulsions, and usually nausea and vomiting. The pulse was quick and irritable, and there was great thirst and restlessness. Occasionally there was no sweating. There was scarcely any urinary or fæcal evacuation; but perspiration broke out in the milder cases, and urine was largely secreted at the same period. A papular or vesicular eruption sometimes followed the perspiration. Relapses were

frequent and common. The skin was highly sensitive to temperature, and the perspiration was very sour and offensive.

772. Hence the general character of this epidemic was that of fever in an intense form, and it affected essentially the parts of organic life. The perspiration was not an essential feature, although it was the most perceptible one.

773. This disease was truly English, for although it occurred elsewhere, it commenced in England, and was known as the English sweating sickness.

774. There were, however, epidemics offering different characters, which appeared at this period in the various parts of Europe. Thus, putrid fevers with phrenitis prevailed in Switzerland and Germany about 1480. A petechial fever occurred in Italy in 1505 of a highly contagious character, and marked by most intense prostration of the vital powers, and was especially fatal to children in the upper ranks of society.

775. Previous to this time the syphilitic disease had widely spread and infected the people of southern Europe. Influenza appeared in 1520, and often reappeared during the 16th century, having much of the characters which are exhibited by the same disease in our own day. The French army of nearly 30,000 men were destroyed before Naples in 1528 by fever, which arose in the swamp in which they were encamped, and a pestilential, highly inflammatory fever, called the trousse galante, ravaged France in the same and the following years.

776. Hence during the first third of the 16th century, the whole of Europe was subject to visitations of disease, which proved to how low a point the vital powers of the human constitution had fallen.

777. We have already referred to the occurrence of the plague in London in the 17th century, viz., 1593, 1603, 1625, 1636, and 1665, which, after an interval of nearly half a century, and within 70 years, destroyed 239,696 persons in London alone; and which, terminating with the great fire of London, passed away for ever. It is again remarkable that the period of recurrence of these epidemics after they had begun to appear was about twenty-two years or the half of that period, being ten years, twenty-two years, eleven years, and then twenty-nine years in their order.

778. But although the plague was finally arrested in London in the 17th century, it continued in other parts of the world, and other diseases of an epidemic nature, but often fatal character, took its place in England. In the 18th century the plague was very fatal in the north of Europe, from 1707 to 1710; in Asia in 1718; in Sicily in 1743; in Morocco and Turkey in 1750-1; in various places in 1757; in Turkey in 1770; and in Bohemia in 1772. Scarlet fever, spotted and yellow fever, and malignant sore-throat, prevailed greatly in America in 1702, 1737, 1743, 1746, 1771, 1773, 1783, 1785, 1792, 1794. Influenza prevailed throughout Europe in 1707, 1729,

1744, 1757, 1782, and 1788; and in America in 1757, 1762, 1772, and 1781. There was great pestilence in England in 1702; head affections in 1712; smallpox, 1723; measles, 1796; and a murrain in horses and cattle in 1751 and 1783; besides the epidemic of influenza, in which England shared with other parts of Europe. It must also be borne in mind that typhus fever, of a low and virulent type, was common and widely spread, and particularly found in the gaols and workhouses, and in the crowded courts of London and other large towns.

779. The 19th century has been remarkable for the attacks of cholera which occurred in England, first in 1832, then in 1849, and a third time in 1854, and on each occasion caused great mortality. The same disease appeared in India at an early period in this century, and at the time of its occurrence in England it was extensively distributed over Europe and Asia. Influenza was very prevalent and fatal in 1801 and 1847. At the present time the plague and typhus fever may be said to have left this island, and smallpox has greatly declined; but typhoid fever, measles, and scarlet fever still exist. Cholera and influenza may be again expected, and diphtheria appears to have recently taken the place which the malignant sore-throat of former years occupied.

780. Hence, whilst some forms of temporarily fatal disease have disappeared, others have arisen, and many remain which were known to have existed before the Christian era; so that whilst mor-

tality is lessened, we are yet exposed to the conditions of epidemic disease already mentioned, viz., the unwonted influence of external agencies, or a temporary defect of the powers of the system to prevent the occurrence of disease.

781. *Causes of Epidemics.*—Having thus in a very rapid manner glanced at the principal periods of pestilential visitation, we will offer some observations on the conditions of society and the meteorologic phenomena which were associated with them, and shall be able to show how closely many of those conditions were associated with depression of the vital powers.

782. In a former part of this work we have proved that the effect of any exaggeration of seasonal conditions is to increase disease, and that long-continued heat most powerfully depresses the vital powers. This has hitherto been proved only in reference to the hot season of a year, but there is the greatest probability that it acts also in a cycle of years, for it is well known that the inhabitants of hot climates are far more prone to succumb to the attacks of disease than those inhabiting temperate regions. Hence it is highly probable that a cycle of years of unusual temperature would tend to lower the powers of the human constitution.

783. The influence of famine and drought, when those disasters are spread over lengthened periods, must be the same in nature as that of deficiency of food in the poorer classes of society. That want of food lowers the vital powers, and that persons so circum-

stanced are the first to fall into disease, are undoubted, and hence famine must be a direct cause of disease. The effect of inundations, of swampy lands, of large dense forests, of accumulation of filth, of crowded dwellings, and of intemperance or other errors of dietary, will be readily admitted as causes of disease, and will affect a community or an era precisely as they prevail. The presence of an unusual development of animal and vegetable life at the periods of pestilence is not in itself a cause of an epidemic, but it shows that the conditions which are by continuance unfavourable to the maintenance of the powers of the human system are favourable to the development of certain other forms of organised beings. A pestilence occurring amongst cattle at the same period as pestilence amongst men may show that both are due to a common external cause; but it is probable that the same cause acts alike upon the animal system.

784. So in like manner we might show that national anxiety must have the same depressing effect upon the health of a nation that the anxieties of life have upon individuals, and it cannot be denied that the latter is a most fruitful source of bodily exhaustion.

785. Hence if it be shown that any, or all, of the above-mentioned conditions have existed in any people during lengthened periods, we shall find a high probability of the occurrence of waves of decrease of the vital powers, which will include a more ready disposition to set up disease, less power to resist adverse

influences, and variation in the methods of treatment of disease; and we believe that there will be no difficulty in furnishing sufficient proof.

786. In the period from 1333 to 1351, during which the Great Mortality existed, there were remarkable changes in the social condition and the meteorology of nearly all the civilised world, as Hecker has clearly shown. There was a parching drought and famine in China and throughout the cities of Europe, so that want, misery, and despair were general throughout Christendom. The order of the seasons was inverted, and rains and floods destroyed the seed, and failure of the crops was universal.

787. Earthquakes and strange meteoric appearances occurred very frequently in several parts of China, in Cyprus, Greece, Naples, Rome, Pisa, Bologna, Padua, Venice, and other parts of Italy; Basle, Germany, France, England, Denmark, Poland, Silesia, and the far north. An eruption of Mount Ætna occurred. Pestiferous winds of a foul odour preceded the earthquake, or issued from the chasms of the earth, or were produced from decomposing animal and vegetable matter. Swarms of locusts destroyed vegetation in China and Franconia, and spread from east to west, darkening the sun, and poisoning the air with their decomposing bodies. The rivers were polluted by thousands of corpses; the air was infected by the multitude of bodies hastily buried or left exposed in the streets; intense fear occupied the

minds and exhausted the courage of men, so that they left every occupation and their wealth, and wandered away to die alone, or having taken the infection, they resigned themselves to what they believed to be their inevitable fate. The closest ties of kindred were loosened, and all fled from the plague-stricken ones. The mental shock sustained by all nations was without a parallel. A solemn sense of contrition seized mankind, and a determination to repent and forsake vice, and to make restitution for past offences, was general. According to the spiritual darkness of that period, they sought by self-chastisement to avert punishment for their sins, and so general was this, that the Order of Flagellants, which had been established some centuries before, assumed large proportions, and multitudes, clad in sombre garments, with red crosses on the breast, back, and legs, and with triple scourges tied in three or four knots, in which points of iron were fixed, went in solemn procession through all the towns of Italy, France, Germany, Hungary, Bohemia, Flanders, Poland, and Silesia, until their numbers, the admixture of the vilest characters, their immoral practices, their general opposition to the Church, and the means which they were of spreading the plague from town to town, led to their suppression by the most violent and determined methods.

788. The condition of the drinking water seems to have attracted early and general attention, and to have excited a greater influence over this epidemic than has hitherto been assigned to it. It was generally believed

to have been poisoned, and the Jews, who were regarded as the poisoners, were treated with the utmost barbarity, so that tens of thousands voluntarily burnt themselves and their goods to avoid the inhumanity of their Christian enemies. But when it is recollected that the cities at that period were commonly enclosed with walls and surrounded by a filthy ditch, that the houses were small and low, the streets narrow and dark, the inhabitants crowded together, and filth was universal, we may readily find natural reasons for the impregnation both of the wells and of the air with poisonous matters.

789. After this period morals were deteriorated everywhere, and the service of religion was in a great measure laid aside. Covetousness became general, disputes about inheritance were universal, lawyers were nearly as great a pest as the locusts, and the services of the Church were confided to the lowest and most ignorant people. A greater fecundity of women was also observed, so that marriages were universally prolific, and twins and triplets were frequent.

790. Hence it appears that in connexion with this frightful scourge there were unusual meteorological commotion, and general anxiety and privation, over the widest area. As the epidemic advanced slowly from the far east to the far north, the minds of men became paralysed with fear, so that, during a space of fifteen years in the east and south, and of nineteen years in the north, the constitution of the inhabitants

of the then known world was subject to these deteriorating influences.

791. There were some physicians who, in that early period, attributed these diseases to extensive putrefaction of animal (*locusts*) and vegetable bodies and terrestrial corruption, with the addition of the evils of bad diet and want.

792. Hence, without knowing very much of the conditions of the inhabitants immediately preceding this great disaster, it is clear that the human system was influenced by causes of a growth which was slow at first, and then became frightfully rapid, followed by a return to the usual condition, and, at length, by an improvement in public health to a point far above anything which had ordinarily existed.

793. Such were the conditions attending the great plague of the 14th century, and although the epidemic itself subsided after a considerable period, the universal excitement continued in some degree and led to the occurrence of the dancing manias to which we have referred. For more than one generation the minds of men were kept in a state of perpetual excitement by political changes and religious influences—conditions specially tending to the increase of nervous affections, and very influential in rendering the constitution of men more liable to succumb to the influence of all adverse agencies. The effect of the religion of the day is thus well described by Hecker:—

794. "The influence of the Roman Catholic religion, connected as this was in the Middle Ages with the

pomp of processions, with public exercise of penance, and with innumerable practices which strongly excited the imagination of its votaries, certainly brought the mind to a very favourable state for the reception of a nervous disorder. Accordingly, so long as the doctrines of Christianity were blended with so much mysticism, these unhallowed disorders prevailed to an important extent, and even in our own days we find them propagated with the greatest facility where the existence of superstition produces the same effect in more limited districts as it once did among whole nations. But this is not all. Every country in Europe, and Italy perhaps more than any other, was visited during the Middle Ages by frightful plagues, which followed each other in such quick succession that they gave the exhausted people scarcely any time for recovery. The Oriental bubo-plague ravaged Italy sixteen times between the years 1119 and 1340. Small-pox and measles were still more destructive than in modern times, and recurred as frequently. St. Anthony's fire was the dread of town and country; and that disgusting disease, the leprosy, which in consequence of the Crusades spread its insinuating poison in all directions, snatched from the paternal hearth innumerable victims, who, banished from human society, pined away in lonely huts, whither they were accompanied only by the pity of the benevolent and their own despair. All these calamities, of which moderns have scarcely retained any recollection, were heightened to an incredible degree by the Black Death

(the Great Mortality), which spread boundless devastation and misery over Italy. Men's minds were everywhere morbidly sensitive, and as it happens with individuals whose senses when they are suffering from anxiety become irritable, so that trifles are magnified into objects of great alarm, and slight shocks which would scarcely affect the spirits when in health give rise in them to severe diseases, so was it with this whole nation, at all times so alive to emotions and at that period sorely pressed with the horrors of death."

795. If in this passage we substitute the idea of the whole organisation or constitution of man for the word "mind" we shall have a juster conception of the subject, and be well impressed with the fact that during several generations there was a general enfeeblement of the human system, as shown by its proneness to put on marks of disease.

796. The foregoing causes of disease were of a public and almost universal character, but it is probable that the sweating sickness and the hysteria which prevailed in the 15th and 16th centuries were at least in great part due to social causes which acted over a more limited area, but were equally efficacious in their respective spheres of action.

797. Thus Dr. Hecker is of opinion that the outbreaks of hysteria were chiefly due to the unnatural restrictions with which women were bound at that period, and which found relief in the violent dances which were then resorted to as remedial agents. He

says, "Lonely and deprived by cruel custom of social intercourse, that fairest of all enjoyments, they dragged on a miserable existence. Cheerfulness and an inclination to sensual pleasures passed into compulsory idleness, and in many into blank despondency. Their imaginations became disordered—a pallid countenance and oppressed respiration bore testimony to their profound suffering. How could they do otherwise, sunk as they were in such extreme misery, than seize the occasion to burst forth from their prisons and alleviate their miseries by taking part in the delights of music? Nor should we here pass unnoticed a circumstance which illustrates in a remarkable degree the psychological nature of hysterical sufferings, namely, that many chlorotic females by joining the dancers at the Carnevaletto were freed from their spasms and oppression of breathing for the whole year, although the corporeal cause of their malady was not removed."

798. It is however necessary that to this account should be added the wicked desires and deceits of a roving population—the mercenaries of war—men of the vilest passions—who joining in these dances received personal gratification from their continuance, until at length their conduct attracted attention and aided in bringing about a revulsion of public feeling whereby the immoral practices which attended these exhibitions were at length brought to a close.

799. The causes which have been assigned for these various epidemics were chiefly poverty, famine,

humidity, and the distribution of the bands of mercenaries, or the Landsknechte, over the country, carrying with them diseases and habits which were the most pernicious to the health and morals of themselves and those with whom they became associated. The first eruption of the sweating sickness occurred with the advent of the Duke of Richmond's army in August 1485, which was composed of the vile refuse of the French mercenaries. It is also probable that the second occasion of its occurrence was associated with the same cause when the troops had been distributed over the country by the disbanding of the army. The Landsknechte were as much the spreaders of contagion at this time as the Crusaders were of the leprosy at an earlier period. But in addition to this there was at both of these periods great anxiety amongst the people, the former in connection with the long continued civil wars of the Roses, and the want and desolation which always succeeds to war. It is also said that the oppression and avarice of Henry VII. indirectly led to the destitution of a large portion of the agricultural population.

800. The cause of the third outbreak of the sweating sickness is not clear, but Dr. Hecker has associated it with the social habits of the English, which it is interesting to our purpose to consider. He says, "That next to the peculiar constitutions which England imparts to her inhabitants, the predisposing causes of the sweating sickness lay in the habits of the English at these times no one can

possibly doubt. The limitation of the pestilence to England plainly indicates this." "Of intemperance, which most generally lays the foundation for disorders, both high and low were at this time accused. This vice in the English was proverbial in foreign countries. Flesh meats highly seasoned with spices and indulged in to excess; noisy nocturnal carousings were become customary, and it was also the practice to drink strong wine immediately after rising in the morning. Cyder, which in some parts, as for instance in Devonshire, is the common beverage, was even in these times considered by medical men as injurious, for it was observed that its use caused debility and paleness, and sapped the vigour of youth of both sexes." It would also appear that there was almost an entire absence of culinary vegetables, and that excess of clothing was common, whereby the skin was rendered unnaturally sensitive and active, and leading to catarrhs. Hot baths and diaphoretic medicine were also commonly used at that period.

801. It is perhaps necessary to remark upon the above extract from Hecker's work, that the vice of intemperance was by no means confined to England, neither perhaps did it attain its maximum influence here, for we find that amongst the sister race in Germany it was so prevalent, that Emperors were required by oath to avoid it, and that one of the regulations of the "temperance societies" which were then established, required that no member should drink more than fourteen cups of the country

wine per day! Hence it may be inferred that the beer-loving inhabitants of *Vaterland*, as we find them to-day, had progenitors, who had no great antipathy to the representative of beer in the Middle Ages.

802. Such is a summary of the political and social causes which acted in an intermittent manner in the Middle Ages in producing epidemic disease, but besides them there were others of a meteorological and physical character. For instance, in the 15th and 16th centuries, great inundations of the country occurred about the period of the advent of Richmond's army, and at the siege of Naples, and were especially important in England, Italy, and Germany from 1527 to 1529. Privation, famine, and fever followed upon them until 1534, in various parts of Germany, France, Italy, and England, and unusual characters of the seasons were recorded.

803. It has been very common to refer the origin of pestilence to the approach of comets, and since more than 500 comets have appeared during the Christian era, and their occurrence is still regarded with dread, it was natural to associate them with any evil arising at the same epoch. So in like manner an unusual development of animal and vegetable life, as the appearance of large flights of locusts, or of multitudes of caterpillars, or the occurrence of lichen, or blood spots, have been regarded as causes of disease, as in our day we have sought to connect the unusual occurrence of flies and fungi with the cholera and the potato disease. In the 16th

century all these supposed causes of disease were very prevalent.

804. Such is a rapid survey of the recorded causes of epidemics in the Middle Ages. Their nature was very various, and the influence which they severally exerted must have varied in different parts and under varying circumstances, but on considering them in even a superficial manner, it is impossible to deny that they must have influenced the health of the community, and caused changes in the human constitution which extended over lengthened periods.

CYCLE OF THE GENERATIONS OF MAN.

CHAPTER XII.

CHANGES IN THE SOCIAL HABITS AND IN THE TYPE OF DISEASE IN THE 19TH CENTURY.

SOCIAL CHANGES.

805. WE will now glance at certain conditions which are of slower and quieter development than those already referred to, but which are as real and influential in their character as any which could be quoted.

806. Every nation must pass through consecutive phases of its social character of a very distinctive kind, from its early origin in barbarism to its highest attainments in civilisation, and although the progression may vary greatly in rapidity, and even retrogression may appear for a period, there will be in the course of ages such a general concurrence in the course of events, that society may be regarded as always advancing. It would serve no good purpose to refer

to the particular social habits and circumstances of society in the barbarous period of its history, since we could only cite general facts which are familiar to every one, such as insufficient shelter, uncertain food, insecurity of life, and exposure to miasmata from waste land, gigantic forests, and inundations of the beds of rivers, all of which must have exerted a most prejudicial influence notwithstanding the counteracting effect of exertion, fresh air, mental excitement, and probably the lack of appreciation of the evil conditions in which they were placed.

807. But it is to be remarked that many of these conditions are continued far into the history of a civilised community, and that when there is a Sovereign and an established form of government, wealthy proprietors, and tolerably large communities, they by no means pass away. Such we have seen to have been the cause of much of the evils of the 14th century, when the barons were powerful and the sovereign weak, and in the 16th century during the wars of the Roses.

808. Dr. Southwood Smith, in his lectures upon epidemics, lays down five conditions as essential to civilisation, and shows how utterly they were set at nought at the period of "the Great Mortality," and in great part down to the 16th century. These are: Sovereign authority; laws incorruptibly administered; physical comfort generally diffused; intellectual development and activity generally diffused; and recognition of the fundamental principles of religion

and morality. But at the period in question the king was nearly powerless; the barons were tyrannical; violence, bloodshed, and robbery were universal; two-thirds of the country were moor, forest, or vast swamps; the houses were small and squalid, built of wood, mud, or wattles, and thatched with straw, without chimneys or conveniences; the floors without boards or bricks, and covered with straw or hay, which remained for months saturated with reeking filth; the streets were narrow, tortuous, unpaved, and with uncleansed gutters, and covered with filth and garbage; the towns were surrounded by stinking ditches; there were few fresh vegetables; the meat was eaten salted throughout the winter; the cattle were without store of fodder; the roads throughout the country were uncared for, and almost impassable; there was a want of fuel amongst the poor, and intemperance and debauchery were almost universal.

809. Such a picture of social conditions, when compared with those of our day, seems to carry us back to the remotest eras of barbarism, and yet, in truth, it was applicable to all nations, and to many parts of Europe up to a recent period. These, and such great events as the upheaving of society at the Reformation, the various periods of marked religious persecution, and times of protracted wars, whether of a civil or external character, causing dear food, general inquietude, and loss of the natural protectors of families, would doubtless cause disease, and modify the human constitution; and when reinforced by the

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influence of meteorological or other external agencies, would induce cyclical conditions, ending in great epidemics.

810. But we are enabled to discuss this matter in a very general way only, since we are familiar only with the more striking changes in the habits of society, and with the most marked eruptions of disease, and cannot, therefore, trace the lesser changes step by step, or prove the precise extent of the variations in the human system. Hence it is fortunate that we are enabled to refer to a change which has occurred in our own time, by which the system is less able to tolerate the influence of heroic treatment, whilst, at the same time, we are witnesses to the alteration which has occurred in the habits and manners of society; and may, therefore, with some degree of certainty, trace the relation of the one to the other. We think it may be interesting to consider the period carefully, for if we can show that a change has passed over the human constitution, which is due to a change in our social habits and relations, it will afford the strongest presumptive evidence that such must have often occurred in the History of the World.

811. We will therefore proceed to point out the marvellous social changes which have occurred during the present century, viz., during the memory of multitudes now living, and we think that it cannot fail to show that they must have exerted an important influence over the human constitution.

812. *The town population has vastly increased and in a greater ratio than the country population.*

813. The total population of Great Britain in 1801 was 10,578,956, whilst in 1851 it had increased to 20,959,477, or an increase of 98·1 per cent. Thus within 50 years the inhabitants of this country have increased as much as has occurred in all previous ages, and the increase in the ten years from 1841 to 1851 was itself equal to the whole increase during the latter half of the 18th century.

814. The town population had increased in nearly a double ratio, for in 212 principal towns there were only 3,046,371 inhabitants in 1801, whilst in 1851 they contained 8,410,021 persons, or an increase of 176·7 per cent. Fifty-one manufacturing towns increased in population on the whole from 722,388 to 2,341,791, or no less than 224·1 per cent., but when considered individually the increase amounted to 351·5 per cent. in the towns devoted to straw-plait working.

815. Large towns have so much increased that whilst there were only twenty-three with a population of 20,000, eight with a population of 50,000, and one with 100,000 inhabitants, there were in 1851 seventy towns with 20,000, twenty-nine with 50,000, and eleven with 100,000 inhabitants.

816. In 1801 the proportion of the population residing in towns of upwards of 20,000 inhabitants was 23 per cent. of the whole community, but in 1851 it had increased to 34 per cent.

817. The following table most significantly shows

how great and rapid has been the growth of our manufacturing towns during the present century, and that some of these have increased more than fourfold.

TABLE No. 53,
SHOWING THE POPULATION IN THE LARGE TOWNS IN 1801, 1851, AND 1861.

Town.	1801.	1851.	1861.
Bradford	13,264	103,778	106,218
Birkenhead	110	24,285	
Birmingham	70,670	232,841	295,955
Cheltenham	3,076	35,051	39,590
Derby	10,832	40,604	43,091
Edinburgh	81,404	191,221	
Glasgow	77,058	329,097	
Leeds	53,162	172,270	207,153
Leicester	17,005	60,584	68,052
Liverpool	82,295	375,955	443,874
London	958,863	2,362,236	2,803,034
Manchester and Salford	94,876	401,321	460,018
Merthyr Tydfil	10,127	63,080	83,844
Nottingham	28,801	57,407	74,531
Preston	12,174	69,542	82,961
Plymouth	16,040	52,221	62,823
Stockport	14,830	53,835	54,681
Stoke-upon-Trent	23,278	84,027	101,302
Sheffield	45,755	135,310	185,157
Wolverhampton	30,584	119,748	147,646
Wigan	10,994	31,941	37,657
Walsall	8,538	25,680	37,726
ENGLAND AND WALES.			
Population	9,156,171	18,054,170	20,223,746
Houses	1,633,399	3,431,533	3,927,788

818. Since, therefore, the whole population both of the country and the towns has so greatly increased, it follows that the inhabitants are now brought nearer together and that a greater number live on any area. In London in 1801 the average distance between the inhabited houses was fifty-seven yards, and between person and person twenty-one yards, but in 1851 those numbers were reduced to thirty-eight and fourteen yards. There were also more than 20,000 square yards of country to every inhabitant in Great Britain in 1801, and 23 acres of land to every inhabited house; but in 1851 the density had increased to one person on 10,090 square yards and one inhabited house to every 11 acres. The distance throughout the country between house and house was in 1801 364 yards, and between person and person 152 yards, but ten years ago these numbers were reduced to 252 and 108 respectively. In 1801 there were 5·4 acres of land to every person living, but in 1851 the space was reduced to 2·7 acres. Indeed the increase of the towns has been so great that at the latter period there was a number of persons living in the towns equal to that living in all the villages and isolated places throughout the country.

819. Our object in referring to these facts is not to show the increase of numbers devoted to any particular occupation nor the absolute or relative decrease which has been shown to have occurred in the agricultural population during the present century,

but simply to prove in how great a degree the inhabitants of this country have changed their mode of living during the short period under consideration and have exposed themselves to all the evils which are associated with large aggregations of individuals.

820. *There is now much less bodily exertion made in the open air.*

821. The yeoman and his dame rode on the same horse to church, or to market, or travelled in a cart without springs, and on roads not macadamised. Now the horse is left at home, and the railway or the omnibus is the universal conveyance. We have shown that the effect of riding upon horseback at the trotting pace was about four times the effect of rest, but now we travel by railway with an increase of only half more than the amount at rest. It required three hours to travel 20 miles on horseback with this large expenditure per hour, but now people travel more than that distance in one hour, and make but little more exertion than if they sat on their hard stools at home. Let this be multiplied until it represents the actual travelling of the members of the community, and then notice in how vast a degree the omnibuses and cabs of our times lessen the amount of walking required, and we cannot fail to observe, that whilst travelling has marvellously increased in our day, the exertion of travelling has decreased in even a greater ratio. This is a most signal feature of the times, and one to the importance of which the attention of men of science has not been sufficiently directed, but the

more its vastness is appreciated, the more the conviction is urged upon the mind that it must have affected the human constitution.

822. *Habits of intemperance, or of the general use of alcoholic liquors, have greatly lessened.*

823. It is now infamous to become drunk at a friend's table; it is no longer necessary to hand the glass of wine at the morning call; the habit of health-drinking is becoming very restricted; the use of wines with but little alcohol is increasing; children are not offered the glass; women less commonly drink strong ales; and in general, throughout society, there is both less proportionate intemperance, and less general use of some alcoholic compounds.

824. The effect of alcohol in health has been already shown to be to excite all the functions of the system—to impede the excretive process, and above all to lessen the dispersion of heat from the body; and hence with its general use, it must follow that the system would be excited, and the skin dry—the conditions tending to inflammation or to inflammatory fevers. It has also been shown that the disturbing power of alcohol tends to cause the retention of urea, and with the highly nitrogenous diet of former times, this must have been an important action.

825. In this discussion it is far more important to regard the general diminution in the use of alcohol than that of intemperance, for whilst the latter might more certainly shorten life, the former would be more likely to control the constitution of the individual,

and therefore of the community. The latter is the true effect of alcohol, the former leads to modified results by inducing reaction. It is impossible not to consider this vast change in the habits of our community, without being assured that the state of the system and its liabilities and dangers must be now widely different from that of the period passed away.

826. *Excess in nitrogenous food is lessened.*

827. This is intimately connected with the former subject, for the action of alcohol with excess of food is far more likely to lead to excess of action than with defect of food, and in the times referred to both were found together. Now, we think it may be affirmed that the amount of nitrogenous food supplied is greatly lessened, both because the total amount of nutriment taken is less, and because there is less meat, cheese, milk, and beer, taken than heretofore. It must be borne in mind, that the breakfast, at 6 to 7 A.M., the dinner, at 11 to 12 A.M., and the supper, at 6 P.M., were all alike substantial meals, and consisted of meat and the kindred elements. Even the farm labourer would have his 1½ pint of milk porridge followed by several ounces of cold bacon for breakfast and supper.

828. At the present time tea and coffee have almost universally taken the place of milk, and thus given that which will yield but a grain or two of nitrogen at a meal, instead of the pint of milk with its 48 grains of nitrogen. Many take only a little bread and butter with it, whilst scarcely any add more than an

egg or a small quantity of bacon. Hence with the milk has gone also the meat. The mid-day meal to the labouring classes is probably not much inferior to that of former days; but to others it is simply a lunch, and offers little nourishment. Hence, to the latter, there is the long interval between the breakfast at 8½ A.M. and the dinner at 6 P.M., in which the body must chiefly live upon its own stores, and when dinner comes, although it be abundant, the nutriment is supplied at a period of the day when the vital action begins to decline, and when the food is apt to pass away undigested. After this may follow a cup of tea and coffee, and the alimentation of the day is brought to a close.

829. The question here is not whether this mode of living is still in excess or otherwise, but that it supplies far less nitrogenous nutriment than that of days gone by, and of this no one can have any reasonable doubt.

830. *Later hours of retiring to rest and of rising are adopted.*

831. The late hours of retiring to rest prolong the period in which the vital actions are elevated and the system wasted, whilst they prevent that repose and repair which the natural declension of the vital powers shows to be required.

832. In like manner the late rising prolongs the sojourn in the unhealthy air of the bed-room, opposes the increase in the vital actions which Nature desires, retards the supply of nutriment, and prevents exertion

in the cool and fresh morning air. Hence both of these evils manifestly tend to lower the vital powers.

833. *The struggle of life is more arduous.*

834. The increased anxieties of life with the labour of the mind lower the exuberant buoyancy of the animal spirits, interfere with muscular exertion, lessen the appetite for food, and lower the tone of all vital actions. In this enumeration we refer simply to the interference with the functions of the body, and omit all reference to the supposed increase of exertion due to mental labour; for the latter is at any rate not established, whereas the former is patent to all. The true student is known by his tameness, pallor, weakness, defective appetite, and general nervous debility, and not by riotous exuberance of spirits, powerful muscular development, general excitement, and fulness of the system.

835. *The clothing of the body is less sufficient.*

836. We must also mention here the change which has taken place in clothing, for whilst a reaction has sprung up and warmer clothing is again become common, there can be no doubt that the knitted worsted hose, gloves, and comforter, the thick calico shirts, the heavy oiled boots, and the great over-coat were better conservators of heat than any which have been common during the last forty years. This certainly applied more to females than to males, and the thin calico or muslin dress, cotton or silk stockings, pump soles, and gossamer bonnets, form poor substitutes for the lamb's-wool stockings, thick shoes,

linsey dress, and velvet or well-lined straw bonnet or hat, and good red cloak which our grandmothers wore. So far as the present system of clothing is deficient in retaining the heat of the body, and is conjoined with the diminished amount of food to which we have referred, so far must it have tended to lower the vital powers of the constitution.

837. *The evils of large towns are increased.*

838. To these various changes we fear that we may add an increase in sexual excess, and in the use of tobacco (except amongst women), and a disposition to earlier marriages, all of which have a tendency to lower the powers of the human constitution. The vast increase of our large towns, in their effect of leading to impure air, immoral habits, general excitement and mental strife, late hours, deficient bodily exertion, by which ten millions of the community are drawn away from the advantages of the country, are manifest causes of change.

839. *The crowding together of large masses of people has been greatly increased.*

840. The institution of public charities may almost be said to have originated in this age, so largely have they increased. This is emphatically the case with hospitals, workhouses, and benevolent institutions for the relief of almost every kind of physical evil; and hence, whatever evils attach to the system, they have acted upon the present generation. We may cite the notorious pauper establishment at Tooting, with its 100 cubic feet of air for each inmate, and workhouses

affording even a less space for each person; and add to them the disgraceful overcrowding of our barracks, in some of which it is said that there is not more than 40 to 50 cubic feet of air for each soldier, and the air is so offensive in the morning that the non-commissioned officer cannot enter it; and also the wretched conditions of our gaols at the beginning of this century. Overcrowding in houses and in narrow streets was well known in every town in Europe, and still exists in a large portion of them, but the increase of the evil in the crowding of great buildings as well as its remedy have been left for our day.

841. At the present time the evils of the system are well known, and it is probable that the due habitation and ventilation of our public buildings will be effected even before the full improvement in the dwellings of the poor shall have been brought about.

842. In reference to our modern buildings and to the dwellings of the middle and upper classes, the evil has already disappeared.

843. *Our drainage system has removed some evils and transferred others.*

844. It is impossible not to notice the beneficial effect of our sanitary arrangements in cleansing the streets, and the yards and basement floors of our houses, whereby putrifying matter has been removed from human habitations. The abundant supply of water has been useful as a necessary part of the cleansing system; and in proportion as it is of a better quality than was heretofore attainable, it must

have improved the condition of health. But this is a subject which admits of consideration in two aspects. The connection of our water-closets with the sewers, and the emptying of their contents into the rivers whence water has been taken to supply the wants of man, is not an unmixed good, and was clearly an unphilosophical mode of hiding a nuisance. It is very probable that the evils which led to this cause were unduly exaggerated by those whose professional duties led them to report upon them, and caused a waste of money, and an oppression of both landlords and tenants to a degree which has never been generally appreciated. Villages with few inhabitants, with natural facilities for surface drainage, where the amount of disease was scarcely above that of the most favoured places, and where well and spring water was attainable, and could have been made abundant, have been afflicted with expensive officials, meddling boards, huge systems of water-works, and frightfully increased amount of taxation, all of which have led to party and private animosities, which will endure at least through this generation; and, in the end, there has been a vile desecration of the only clear purling brook which adorned the neighbourhood. It is probable that in many cases the well water in our villages and towns was contaminated, and therefore injurious; but now, in other cases, the coolest and the purest water which these places afford is rendered valueless by the introduction of water varying greatly in temperature, and left in cisterns, in which offensive

mud lies at the bottom, and cryptogamous plants thrive at the top.

845. Under the old system, the drainings of foul sewers occasionally found their way into the wells; but under the new, we drank the filth bodily, until the repeated outbreaks of cholera arrested public attention, and took our sanitary arrangements, at least in part, out of the hands of men whose education had had reference to bricks and mortar, and not to human health. *Then* the public were oppressed to pay for works which merely transferred an evil from one locality to another, and *now* they must pay to undo that which was then done, but in the end the benefit which will accrue is incalculable.

846. *The actual temperature has increased.*

847. It is also highly probable that there has been an increase of the temperature to which men are exposed, not only from the production of heat, which must increase as a country increases in population, but from the actual temperature in which men pass their lives. This results from the improved shelter offered by the improved construction of houses with boarded floors, well-fitting doors and windows, sound roofs, and thick solid walls; the greater abundance of coal fuel; the aggregation of persons in towns, and the shelter of the railway carriage instead of the long-continued exposure on horseback in travelling. This cannot be measured by the degrees of temperature of the external air, and hence we cannot find an exact method of determining its prevalence;

but since it is the aim of all persons to keep their houses at 55° to 60° at all seasons, and that is also about the temperature of the workshop and the travelling carriage, it appears certain that the improvements of our day have tended to equalise the temperature to which the body is really exposed at different periods of the day and year, and to keep it to that which is the most congenial to the feelings. The effect of higher temperature is doubtless to lessen the amount of chemical change proceeding within the body, and, as we have already seen, to increase the rate of pulsation, but to lessen that of respiration. Hence, it would further tend to lessen the quantity of food which was taken in former times.

848. *The syphilitic constitution is very prevalent.*

849. The introduction of syphilis extends back to an earlier period than that now under review, but its ravages have doubtless been greater during this than in any other period since its first wide distribution in the 15th century, on account of the temptation to immoral habits which has been so greatly increased by the rapid increase of our great towns. It is impossible to define with exactness what influence this agent has exerted over the constitutions of the community; but now that its prevalence is known to be exceedingly great amongst our young men, that it is transmissible in its secondary, and even its tertiary forms, that the mass of children at our dispensaries exhibit well recognised marks of its influence, it

cannot be but that it has infected a very large mass of the people of European nations.

850. Its tendency is to lower the vital powers, both in a great degree and over a considerable period of time, as is seen by the wasting and general cachexia of its victims,—marks which not unfrequently remain throughout life. Indeed, it is admitted to infect the whole organisation, and to modify greatly the accumulative and the formative processes.

851. *The use of tea, coffee, and diluents has increased.*

852. We cannot pass over the general use of tea and coffee without asking if they have been useful in the change which has now been pointed out.

853. Tea was introduced into England in the 17th century, but it has been only within the memory of the present generation (and those not aged) that it has been universally introduced amongst all classes of this country. It is a change of habit of the most marked kind, and acts both by supplanting some other article of food, and by supplying some material of its own.

854. In reference to the supplanting of other food, we have shown that in doing so it has greatly diminished the amount of nitrogenous material which was formerly taken,—such as milk and beer; and, indeed, to this we may add also meat. In this direction, therefore, its action is positive, for it has certainly lessened the nutriment taken. As to its own supply of material, we may remark, that in 50 grains of tea there is not one grain of nitrogen which enters the

system from the infusion both in the theine and the gluten combined; but we know that there is an exhilaration and lightness following its use, and this we have shown to be due to the power of this agent in increasing the elimination of carbonic acid, and therefore of inducing more complete transformation of food.

855. Hence the introduction of tea, (and as coffee has in these respects a very similar action we may add of coffee also), has both lessened the supply of nutriment and made better use of that which is supplied, and hence it has contributed most powerfully to the prevention of accumulations within the system and the most perfect discharge of effête matters. The action is therefore good or bad, according as there is a sufficient supply of food from other sources.

856. Such, then, is a rapid glance at the more prominent changes which have been made in the habits of this nation within the memory of millions still living,—changes so important as the vast increase of town populations, crowding of the people, diminished bodily exertion, increased mental anxiety, lessened abuse of intoxicating drinks and nitrogenous foods, later hours, sexual excesses, spread of the syphilitic constitution, contamination of our drinking water, increase of temperature, and the more abundant use of diluents and nervous excitants. To a large extent they have been shared by other nations, for their elements form part of the great work of civilisation; and although that has progressed at various rates

in different countries, there is scarcely any which has not felt its march. Certainly it applies to large portions of America, Australia, France, Italy, Russia, and other countries in the north, and probably to an extent wider than we can at present appreciate.

857. Is it possible, we ask, to consider attentively these several questions in their relative bearings upon each other, and at the same time to bear in mind how readily the human organism is influenced under our own eyes by circumstances of even transient influence, and not admit that they must have affected the whole community? Disease results from the influence of external agencies or from errors associated with alimentation, and we have shown that in both of these directions the conditions under which men now live are most diverse from those which were almost universal more than half a century ago. Have we not a striking illustration of the effect of alimentation in the circumstances connected with the late Irish famine? With the potato the Irishman lived, and when it failed he died, but since that period the corn crop has been introduced, and with a higher kind of food the fever and the scrofula, which perennially infested the country, have nearly passed away, and now we find both a better organisation and one far less liable to disease. The disease and the type of disease have changed there from this single cause, and can it be otherwise with a community in which changes of a most unparalleled kind have leavened

the very core of society for a long series of successive years?

CHANGE IN THE TYPE OF DISEASE.

858. We have thus far glanced at this part of our subject, because it affords a striking illustration of changes which must have occurred, although in less degree, in the history of every nation, and in various eras of the same nation; for with every succeeding generation there is a change in the habits of society, whether advancing or retrograding; and if we admit their influence now, we cannot deny it in former times. We will now connect the changes in society which have been recorded with the present condition of the human constitution, and offer some observations on the change in the type of disease which has been witnessed by this generation. In the discussions which have occurred on this subject it has been alleged, on the one side, that the character of disease has changed, and that the present mode of treating disease has simply followed the change of type; whilst, on the other side, this change of type is denied, and the altered treatment of this day is based upon improved views of pathology and improved means of diagnosis. In this fierce dispute, as in any other, there is doubtless truth on both sides, and the partisans being assured of the truth on their side, illogically assume there is none on the other.

859. It is impossible to deny that the increased

knowledge of the present day has enabled us to separate conditions which before were believed to form part of one disease, and also that we can detect disease in an earlier stage than was formerly possible. It is in the highest degree probable that the so-called inflammatory fevers of the days of Armstrong and Clutterbuck, which were invariably treated by bleeding, were connected with inflammation of internal organs, as the lungs, or, in many cases, might indeed have been altogether such inflammations. It is also quite certain that the method of auscultation has given us new and highly valuable means of detecting the earliest departure from a healthy state; so that we can readily distinguish pleuritis from pneumonia, and both from pericarditis, and can determine the existence of pleuritis almost before any kind of effusion has taken place, and can point out the first or congestive stage of pneumonia. These are merely patent illustrations, but they suffice to prove that there is much truth on the side of those who affirm that our means of diagnosis have improved, and that we now discover the existence of disease before it has reached the stage in which it was first evident to the physician of former days, and in which, therefore, he would have commenced his system of depletion. It appears to us that it must be idle to deny this, or to attempt to explain it away, for although we, with the stethoscope in our hands and our improved system of diagnosis, may not give that close attention to the general symptoms of the disease which the acute men

of former days gave, and may not therefore either appreciate or recognise them in the same high degree, it is impossible not to know that we have sure marks of disease before there are any external evidences cognisant to the senses. Hence we have increased light, and we use it as our guide.

860. But all this may be true, and yet the truth contended for by the opposite side be admitted also. We think that we have given in the preceding pages abundant evidence to prove that the conditions under which men live, and under which they therefore acquire disease, have greatly changed, and hence to our mind it must follow, that the form and the type of disease must necessarily have changed also. This affords very strong presumptive evidence in favour of the view of the opponents, and to this we must add the talents and truthfulness of men who practised upon the old plan. In this argument we may admit that the nature of disease would vary somewhat in different localities and in different persons, and that it would be wrongly treated in many instances, just as we find those conditions to occur now; but we contend for a general character of disease which, in a very wide area, presents a common aspect to the medical practitioner. If the depleting treatment were thus generally as injurious as it would be in our day, it is
im possible to believe that this would not have attracted attention, or that the leading minds of the profession at the end of the last century were a whit less acute, observant, and conscientious than those of this or of

any other age. At that period mental acuteness had reached its culminating point, and especially in the University of Edinburgh, and attention to the nature and value of general symptoms, and of remedies, was certainly not inferior to any in this day—indeed, taking into consideration the amount of light then and now afforded, we think mental acuteness to have been then far greater than now. The question is not whether they possessed as much knowledge as we do of the kind on which this day prides itself, but it is whether they followed a plan of treatment which was attended with the disastrous results which would attend it now.

861. Indeed, in reference to knowledge in general, it may be affirmed, that whilst there is a progression which has passed through all preceding ages, and will yet continue, each age has had its own standard of truth fitted for the conditions then existing, and to submit to that standard was both due and just. They were as right in their actions as we are in ours, and yet those actions may be very different in character. It is absurd to suppose that whilst all ages have been in search of truth, and each succeeding one, by the labours of the preceding, has been able to make nearer approaches to it—a condition which will doubtless proceed to the end of time—that therefore we have never found it; and that, whilst one-half of our duty is to correct the errors of our predecessors, we, in our day, are the only wise. The conditions under which men live vary as much as does the knowledge which men gain, and what was truth in all ages

might well be regarded as falsehood now, if the conditions of our day necessarily existed in former eras.

862. Then again, there are multitudes of men who can bear witness to the truth that they were as successful fifty years ago as they are now, and yet the plans of treatment are diametrically opposed. The only fallacy in this argument is the uncertainty of mere impressions received on the mind so long ago, but such impressions are regarded as of value when applied to general, historical, or legal knowledge, and we do not see why they should especially fail us here. No doubt as the changes to which we have referred occurred more or less slowly, there would be many who, although cotemporaneous, would vary in their opinion, just as it is certain that those who live in the country, and especially in northern and agricultural localities, at the present day, entertain far different views on the question of the treatment now adopted from those of equal intelligence who dwell in large towns; but regarding the question in a wide sense, the older practitioners approved the former plan in its day quite as much as they approve the very different one of the present period.

863. This, therefore, not only gives us presumptive, but positive evidence, and when we further cite the fact of the great similarity in the results following the treatment of so important a disease as pneumonia, when in the same hospital and at the same time it was depleting, sustaining, and merely expectant, we

can find no difficulty in affirming that the type of disease was different half a century ago, and its treatment was then correct; whilst our improved diagnosis, and the new type of disease, warrant the different method of treatment which we now pursue.

864. It is scarcely possible that the conditions of half a century ago can recur in this country, for habits of excess become daily less unsuited to the feeling of the age, but with the tendency to increase of exertion, with other clothing, and with a more sufficient distribution of the necessities of life, it is very likely that the so-called asthenic type will be modified, and the treatment put on again something of its earlier phase.

865. It has become the fashion to speak of the degeneracy of the system in this day, and to affirm that we are not in strength and build of body equal to our fathers. This has doubtless resulted from the misuse of the term "sthenic," whereby it is inferred that because the type of disease is now less sthenic, the powers of the body are less sthenic also. We do not in the least give credence to these statements. It is as impossible that a system which was bloated by excess, and acting madly or spasmodically by deranged nervous action and reduced consciousness, can be regarded as really strong, as it would be to assume that a system in which all the appetites are duly regulated, and the various vital actions work harmoniously, is not a near approach to that type which was originally created. There was excess, and madness,

and disease, and it was such a state of things that the physicians of those days had to combat; but now there is more uniform health, because there is a more correct balance in the account of want and supply. If in any case the skin be deficient in action, the heart's action excited, and the system full of blood, as a tolerably constant state of things, it may readily be admitted that much depletion in one way or other will be both borne and required; but we maintain that that would be no evidence of true muscular power, or of great vital power, such as is requisite to resist the action of external influences. Under the existing regimen the muscular development may be certainly carried by cultivation to a degree never surpassed, and the body be thus better able to endure fatigue than could be the case under circumstances of excess.

866. It is, however, true, that a spare diet lessens muscular power, and that on this ground chiefly the inhabitants of the Continent are less powerful (644) and less enduring than Englishmen; but, in the former, there is deficiency of animal food to maintain the due assimilation of other food, and to supply abundant material for muscular repair. There is no reasonable fear that the change which has occurred in the habits of the people of this country will have this effect. It is, however, highly probable that, under the former habits there would be less tendency to "take cold," or to submit to the influence of moderate changes of temperature, and also greater power to sustain unusual calls upon the system, as

during exposure and the absence of food. All physiological work is tending to show that there is a store of food in the body apart from mere tissue, as, for example, in the varying volume of the blood, and hence there should be some little excess of supply over waste at every period of life.

CYCLE OF THE GENERATIONS OF MAN.

CHAPTER XIII.

CONCLUSION.

867. On a review of the facts which have been cited in reference to the cycle of the generations of man, we think it may be affirmed that the human system has often varied in its power to resist adverse influences. This has proceeded in almost unobserved waves as the gradual changes in society have rapidly or slowly progressed, and has led to changes in the type of disease and the effect of recognised remedies; or its course has been rapid and obtrusive under the temporary influence of war and famine, personal, domestic, and political influence, and excess of sexual indulgence, until it has culminated in a fatal epidemic. In the present state of society, in which there is comparative peace, security, and plenty, and when moral and intellectual influences are widely leavening the habits of society, it may be expected that the character of the human constitution will become more fixed, but at the same time not less sensitive

to the influence of the powerful agents which, in daily life or under exceptional conditions, affect it. Human life is now undoubtedly prolonged, and this favourable change must still further proceed so long as the conditions of the era favour human health, but with change of conditions must again come changes of health.

868. In summing up this subject, we must remark, that the conditions of each era must be taken as a whole, and considered apart from those of any other. It is impossible to transplant any material part from one period to another, for the whole were indissolubly connected, and one part tended to correct the evils of the other part. Without the rough exertion in the open air, and the accumulation of fluid in the cold undrained country of the last age, we cannot now return to their excess of living, fulness of blood, and necessity for blood-letting, nor without the chinks in the walls and roofs, and the ill-fitting doors and windows of their houses, could we now adopt the bad system of ventilation, the drawn thick curtains of the four-post bedsteads, and the close confinement and heated air in which the sick were then kept. So, on the other hand, our present mild or expectant method of treatment would not have suited their excessive and riotous modes of living, neither should we be justified in pursuing the present system of free exposure of cases of small-pox, measles, and scarlet-fever to the inflammatory condition of those days.

869. The precautions of man, or in other words his

mode of living, correspond with the conditions in which he is placed. Moreover, they are commonly suited to those conditions, and tend to health, except so far that in the onward march of improvement the conditions almost insensibly change, whilst the habits remain the same in that generation, and only change in the instances of the younger branches of families. Hence, as a whole, the habits of the moderate men of the time have been right in each era, but in proportion as any age has improved its material condition, so will the aged have lagged behind, and the advancing generation have hardly kept pace in the adaptation of their habits, and have thus laid themselves open to the reproaches of posterity. So doubtless it will be with the boasted wisdom of this fast improving age, when measured by the advances which succeeding ages will make.

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THE END.

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